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CHAPTER 1

The Language of Chemistry

SUMMARY

1. SYMBOLS

The simplified, abbreviated names of the elements are called symbols. A symbol is generally represented by the first alphabet of the element written in capital letter. If the names of two or more elements begin with the same alphabet, then the first two alphabets are chosen, where the first letter is capital and the second is small. For example, Carbon is represented as C, while Calcium is represented as Ca and Chlorine as Cl.

1.1 Symbols of Some Common Elements:

The symbols for the common elements are as follows :

Elements	Symbols	Elements	Symbols
Hydrogen	H	Yttrium	Y
Helium	He	Zirconium	Zr
Lithium	Li	Niobium	Nb
Beryllium	Be	Molybdenum	Mo
Boron	B	Technetium	Tc
Carbon	C	Ruthenium	Ru
Nitrogen	N	Rhodium	Rh
Oxygen	0	Palladium	Pd
Fluorine	F	Silver	Ag
Neon	Ne	Cadmium	Cd
Sodium	Na	Indium	In
Magnesium	Mg	Tin	Sn
Aluminium	Al	Antimony	Sb
Silicon	Si	Tellurium	Te
Phosphorus	P	Iodine	I
Sulphur	S	Xenon	Xe
Chlorine	Cl	Caesium	Cs

Qualitatively a symbol represents a specific element and one atom of an element.
For example, O represents one element of oxygen.
O represents one atom of oxygen.

2. RADICALS

Radicals are groups of atoms of different elements which behave as a single unit, having their own combining capacity. Positive radicals are called basic radicals or cations, while negative radicals are called acidic radicals or anions.

3. VALENCE ELECTRONS

The number of electrons present in the outermost orbit of an atom is called valence electrons. For example, Carbon (6) has the configuration 2, 4, so it has 4 valence electrons. Oxygen (8) has the configuration 2, 6, so it has 6 valence electrons.
Valency is the combining capacity of an element. It represents the number of hydrogen atoms which combine directly or indirectly with one atom of an element. Valency is equal to the number of electrons lost, gained or shared during chemical bond formation. The valency of hydrogen and metals is positive, whereas non-metals have negative valency.
Variable Valency: Certain elements exhibit more than one valency. If an element has two positive valencies, the suffix 'ic' is used for higher valency and 'ous' for lower valency. For example, Iron shows +2 valency as Ferrous (Fe^{2+}) and +3 valency as Ferric (Fe^{3+}).

4. POSITIVE RADICALS

Monovalent (unipositive)		Divalent (dipositive)	
Potassium	K^+	Calcium	Ca^{2+}
Sodium	Na^+	Magnesium	Mg^{2+}
Cuprous	Cu^+	Barium	Ba^{2+}

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Mercurous	Hg^{+}	Ferrous	Fe^{2+}
Hydrogen	H^{+}	Cupric	Cu^{2+}
Silver	Ag^{+}	Plumbous	Pb^{2+}
Ammonium	NH_4^{+}	Manganese	Mn^{2+}
		Zinc	Zn^{2+}
		Nickel	Ni^{2+}
		Stannous	Sn^{2+}
		Mercuric	Hg^{2+}
Trivalent (tripositive)		**Tetravalent (tetrapositive)**	
Ferric	Fe^{3+}	Stannic	Sn^{4+}
Aluminium	Al^{3+}	Plumbic	Pb^{4+}
Chromium	Cr^{3+}	Platinum	Pt^{4+}
Antimony	Sb^{3+}		

Negative Radicals

Monovalent (uninegative)		**Divalent (dinegative)**	
Fluoride	F^{-}	Sulphate	SO_4^{2-}
Chloride	Cl^{-}	Sulphite	SO_3^{2-}
Bromide	Br^{-}	Sulphide	S^{2-}
Iodide	I^{-}	Carbonate	CO_3^{2-}
Hydride	H^{-}	Oxide	O^{2-}
Hydroxide	OH^{-}	Peroxide	O_2^{2-}
Bicarbonate	HCO_3^{-}	Thiosulphate	$S_2O_3^{2-}$
Bisulphate	HSO_4^{-}	Zincate	ZnO_2^{2-}
Bisulphite	HSO_3^{-}	Stannate	SnO_3^{2-}
Bisulphide	HS^{-}	Plumbate	PbO_2^{2-}
Hypochlorite	ClO^{-}	Manganate	MnO_4^{2-}
Chlorate	ClO_3^{-}	Chromate	CrO_4^{2-}
Perchlorate	ClO_4^{-}	Dichromate	$Cr_2O_7^{2-}$
Nitrate	NO_3^{-}	Oxalate	$C_2O_4^{2-}$
Nitrite	NO_2^{-}	Silicate	SiO_3^{2-}
Permanganate	MnO_4^{-}	Acetylide	C_2^{2-}
Acetate	CH_3COO^{-}	Methanide	C^{4-}
Cyanide	CN^{-}	Ferrocyanide	$[Fe(CN)_6]^{4-}$
Aluminate	AlO_2^{-}		
Nitride	N^{3-}		

Phosphate	PO_4^{3-}		
Phosphite	PO_3^{3-}		
Phosphide	P^{3-}		
Ferricyanide	$[Fe(CN)_6]^{3-}$		

A chemical compound is always electrically neutral.

The positive and the negative valencies of the radicals present in the compound add to zero.

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5. CHEMICAL FORMULA

A chemical formula is the symbolic representation of a molecule of an element or a compound. It gives the exact number of atoms present in a molecule.

Significance:

(i) It represents the name of the compound.

(ii) It gives the number of atoms present in a molecule.

(iii) It represents the actual mass of the substance used.

(iv) It represents the ratios of the respective masses of the elements present in a compound.

For example, the formula H_2O means that:

(a) Molecular formula of water is H_2O

(b) Each molecule of water contains 2 atoms of hydrogen and one atom of oxygen.

(c) The molecular mass of

$$H_2O = \text{Mass of } H_2 + \text{Mass of O.}$$
$$= 2 \times 1 + 16 = 18\,\text{g}$$

5.1 Writing Chemical Formulae:

The method of writing the formula is called CRISS-CROSS METHOD.

The following steps are involved in writing the formula of a compound:

Step I : The symbols of positive radicals with their valency is written on the left hand side and the symbol of negative radicals with their valency is written on the right hand side.

Step II : Divide the valency number by the highest common factor if any. Now interchange the valencies, ignoring the $(^{+})$ and $(^{-})$ signs. Bring the valencies in the subscript.

Step III : Shift the valency number to the lower right of the atom or the radical. If radical receives number more than one, then enclose it in simple brackets. Single atoms are not enclosed in brackets.

6. NAMING CHEMICAL COMPOUND

For naming the chemical compound from the formula, the following rules are followed:

(i) If a compound is binary (containing two elements only), such that one atom is metal and other is non-metal, the metal is named first and non-metal is named at the end with suffix 'ide'.
For example:

Na_2O – Sodium oxide

AlN – Aluminium nitride

(ii) The compounds containing two non-metals are named by using prefix mono, di, tri, etc.
For example:

CO – Carbon monoxide

NO_2 – Nitrogen dioxide

CO_2 – Carbon dioxide

SO_3 – Sulphur trioxide

PCl_5 – Phosphorus pentachloride

PCl_3 – Phosphorus trichloride

(iii) For tertiary compounds, i.e. compounds having three elements, out of which, one is oxygen are named by suffix - ate, if there is only one such compound. If there are two compounds, the one with less number of oxygen is termed with suffix - ite and the one with more number of oxygen is named with suffix - ate.
For example:

Na_2CO_3 – Sodium carbonate

Na_2SO_3 – Sodium sulphite

Na_2SO_4 – Sodium sulphate

KNO_2 – Potassium nitrite

KNO_3 – Potassium nitrate.

(iv) If in a given compound, the number of oxygen is less than oxygen present in a compound ending with - ite, then it is named with the prefix hypo and if it is more than oxygen present in a compound ending with - ate, then it is named with the prefix per.
For example:

NaClO – Sodium hypochlorite.

It contains less oxygen than $NaClO_2$ (Sodium chlorite)

$NaClO_4$ – Sodium perchlorate.

It contains more oxygen than $NaClO_3$ (Sodium chlorate)

7. NAMING OF ACIDS

The acids containing two elements, in which one atom is essentially hydrogen which combines with one non-metal are named by adding prefix hydro and suffix - is to the name of second element (non-metal).
For example:

HCl – Hydrochloric acid

HBr – Hydrobromic acid

HF – Hydrofluoric acid

HI – Hydroiodic acid

If the acids containing radicals and polyatomic groups then names are given on the basis of second group, but the prefix hydro is not used.
For example:

H_2SO_3 – Sulphurous acid
[less number of oxygen atoms]

H_2SO_4 – Sulphuric acid

HNO_2 – Nitrous acid
[less number of oxygen atoms]

HNO_3 – Nitric acid

8. NAMING OF BASES

Bases are the metallic hydroxides, they are named as hydroxides after the name of the metal or radical.
For example:

NH_4OH – Ammonium hydroxide

NaOH – Sodium hydroxide

KOH – Potassium hydroxide

9. CHEMICAL EQUATION

(A) equation is a statement that describes a chemical change in terms of symbols and formulae.

For example :

$$\text{Carbon} + \text{oxygen} \xrightarrow{\text{Heat}} \text{Carbon dioxide}$$

$$C + O_2 \longrightarrow CO_2$$

In a chemical reaction, reactants change into products.

9.1 Reactants:

The substances written on the left hand side of the arrow are called reactants (the substances that take part in a chemical reaction).
For example:

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$$\underset{\text{(Reactant)}}{2KClO_3} \xrightarrow{\Delta} \underbrace{2KCl + 3O_2}_{\text{Product}}$$

9.2 Products

The substances written on the right hand side of the arrow are called products (the substances which are formed as a result of chemical reaction). For example, in above reaction, 2KCl and $3O_2$, are called products.

A chemical equation may involve

(i) One reactant and two or three products
(ii) Two reactants and one product
(iii) Two reactants and two products
(iv) Two reactants and three or four products.

(i) One reactant and two or three products: The following examples can be put under the given category of equations. These equations basically involve thermal decomposition reaction.
   (a) $2Zn(NO_3)_2 \xrightarrow{\Delta} 2ZnO + 4NO_2 + O_2$
   (b) $MgCO_3 \xrightarrow{\Delta} MgO + CO_2$
   (c) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
   (d) $2Ag_2CO_3 \xrightarrow{\Delta} 4Ag + 2CO_2 + O_2$
   (e) $2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$
   (f) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + 4H_2O + Cr_2O_3$

(ii) Two reactants and one product: The following examples can be put under the given category of equations. These equations basically involve synthesis and direct combination reaction.
   (a) $C + O_2 \longrightarrow CO_2$
   (b) $N_2 + O_2 \longrightarrow 2NO$
   (c) $NH_3 + HCl \longrightarrow NH_4Cl$
   (d) $2NO + O_2 \longrightarrow 2NO_2$
   (e) $N_2 + 3H_2 \longrightarrow 2NH_3$
   (f) $S + O_2 \longrightarrow SO_2$

(iii) Two reactants and two products: The following examples can be put under the given category of equations. These examples basically involve the double decomposition reaction (neutralization and precipitation reactions) and simple displacement reaction.
   (a) $KOH + HCl \longrightarrow KCl + H_2O$
   (b) $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$
   (c) $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$
   (d) $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 + 3NaCl$
   (e) $AgNO_3 + HCl \longrightarrow AgCl + HNO_3$
   (f) $CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$

(iv) Two reactants and three or four products: The following examples can be included in the given category of equations.
   (a) $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$
   (b) $K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$
   (c) $PbO_2 + 4HCl \longrightarrow PbCl_2 + Cl_2 + 2H_2O$
   (d) $Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2$
   (e) $Mg + 2H_2SO_4 \longrightarrow MgSO_4 + 2H_2O + SO$
   (f) $Pb_3O_4 + 8HCl \longrightarrow 3PbCl_2 + Cl_2 + 4H_2O$

10. BALANCED CHEMICAL EQUATION

The number of atoms of each element on the left hand side (reactants) of an equation is always equal to the number of atoms of each element on the right hand side (products). Such type of an equation is called a balanced chemical equation.

10.1 Balancing a Chemical Equation

In order to balance a chemical equation, it is essential to know the reactants taking part in the chemical reaction and the products formed as a result of reaction. It becomes more convenient if the equation is written in the form of equations.

1. Hit and Trial Method: A chemical equation is balanced by hit and trial method. Chemical equations are balanced by assigning suitable coefficients to the molecules, wherever necessary. This method will be clear from the following examples.

Example 1: $KOH + HCl \longrightarrow KCl + H_2O$

Element	Number of atoms on	
	Reactant side (LHS)	Product side (RHS)
H	2	2
K	1	1
Cl	1	1
O	1	1

Thus, this equation is a balanced equation.

Example 2 : $Mg(OH)_2 + HCl \longrightarrow MgCl_2 + H_2O$

Step-1:

Element	Number of atoms on	
	Reactant side (LHS)	Product side (RHS)
Mg	1	1
H	3	2
Cl	1	2
O	2	1

Step-2: To balance Cl, put the coefficient 2 before HCl on reactant side (LHS).

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$$Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + H_2O$$

Step-3: To balance O, put the coefficient 2 before H_2O on product side (RHS).

$$Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$$

Step-4: Check the number of atoms of hydrogen, it gets automatically balanced. Thus, the above equation gets balanced.

2. Partial Equation Method: Although hit and trial method is very useful in balancing of the equation, yet this method is very time consuming. However, the balancing can be done more easily by partial equation method.

Examples for the balancing of equation by partial equation method:

(i) Oxidation of carbon to carbon dioxide by concentrated sulphuric acid.

(a) First, sulphuric acid decomposes to give water, sulphur dioxide and nascent oxygen.

$$H_2SO_4 \longrightarrow H_2O + SO_2 + [O] \quad ...(i)$$

(b) Carbon gets oxidized to carbon dioxide by nascent oxygen.

$$C + 2[O] \longrightarrow CO_2 \quad ...(ii)$$

To balance [O], multiply equation (i) by 2 and then, add both the equations.

$$2H_2SO_4 \longrightarrow 2H_2O + 2SO_2 + 2[O]$$

$$C + 2[O] \longrightarrow CO_2$$

$$\underline{C + 2H_2SO_4} \longrightarrow \underline{2H_2O + 2SO_2 + CO_2}$$

Thus, the above equation gets balanced.

(ii) Oxidation of halogen acid to halogen by ozone.

(a) Ozone decomposes to give nascent oxygen.

$$O_3 \longrightarrow O_2 + [O] \quad ...(i)$$

(b) HCl (halogen acid) gets oxidized to give Cl_2 (halogen) by nascent oxygen.

$$2HCl + [O] \longrightarrow H_2O + Cl_2 \quad ...(ii)$$

On adding both the equations,

$$O_3 \longrightarrow O_2 + [O]$$

$$2HCl + [O] \longrightarrow H_2O + Cl_2$$

$$\underline{2HCl + O_3} \longrightarrow \underline{O_2 + H_2O + Cl_2}$$

Thus, the above equation gets balanced.

3. Information conveyed by a Balanced Chemical Equation:

A balanced chemical equation conveys the following information:

(i) It tells about the reactant(s) taking part in the chemical reaction.

(ii) It tells about the product(s) formed in the chemical reaction.

(iii) It tells the number of atoms of each element participating in the reaction.

(iv) It tells the number of molecules of different substances taking part in the chemical reaction.

(v) It tells about the volumes of gaseous reactants and products

$$\underset{1\text{ volume}}{N_2} + \underset{3\text{ volumes}}{3H_2} \longrightarrow \underset{2\text{ volumes}}{2NH_3}$$

1 volume of nitrogen + 3 volumes of hydrogen $\longrightarrow$ 2 volumes of ammonia

(vi) It tells about the masses of reactants and products involved during the reaction.

$$\underset{24\text{ g}}{Mg} + \underset{98\text{ g}}{H_2SO_4} \longrightarrow \underset{120\text{ g}}{MgSO_4} + \underset{2\text{g}}{H_2}$$

24 g of Mg reacts with 98 g of H_2SO_4 to form 120 g of $MgSO_4$ and 2 g of H_2.

4. Limitations of Chemical Equation

(i) A balanced chemical equation does not tell whether the reaction is fast or slow, i.e. it does not tell about the rate of the reaction.

(ii) A balanced equation does not give any idea about the conditions, i.e. pressure, temperature and concentration.

(iii) A balanced equation does not tell about the physical states of the reactants and does not even tell that whether the reaction gets completed or not.

(iv) It does not give any indication regarding evolution of heat or absorption of heat.

11. ATOMIC MASS AND MOLECULAR MASS

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Atomic mass (weight) is the number which represents how many times an atom of an element is heavier than $1/12^{th}$ of the mass of an atom of Carbon –12.

The relative atomic mass of an element expressed in grams is called gram atomic mass or gram atom.

Molecular mass (weight) is the number which represents how many times a molecule of a compound is heavier than 1/12th the mass of an atom of Carbon –12.

The relative molecular mass expressed in grams is called as gram molecular weight or gram molecular mass or gram molecule.

The percentage composition of a compound is defined as the percentage by weight of each element present in the molecule of a compound.

Percentage composition of a compound
$= \frac{\text{Weight of an element in a molecule of a compound}}{\text{Gram molecular weight of the compound}} \times 100$

Relative atomic mass of an element is the number which represents how many times an atom of an element is heavier than 1/12th of carbon 12.

Relative Atomic Mass
$= \frac{\text{Mass of one atom of an element}}{\text{1/2th of mass of an atom of carbon} - 12}$

Relative atomic mass can also be defined with respect to hydrogen. It is the number that represents, how many times one atom of an element is heavier than one atom of hydrogen, whose weight has been taken as unity.

Relative Atomic Mass
$= \frac{\text{Mass of one atom of an element}}{\text{Mass of one atom of hydrogen (weight taken as unity)}}$

Relative molecular mass of a compound is defined as the average mass of one molecule of it as compared to 1/12th of mass of one carbon 12 atom.

Relative Molecular Mass
$= \frac{\text{Mass of one molecule of a substance}}{\text{Mass of 1/12th of an atom of C} - 12}$

Relative molecular mass can also be defined with respect to hydrogen. It is the number that represents how many times one molecule of a substance is heavier than one atom of hydrogen whose weight is taken as unity.

****

OBJECTIVE QUESTIONS

1. Based on their atomicity, how are phosphorus and sulphur molecules classified respectively?
(A) Diatomic and tri-atomic
(B) Tetra-atomic and octa-atomic
(C) Octa-atomic and tetra-atomic
(D) Tri-atomic and diatomic

Ans : (B)

The total number of atoms present in one molecule of an element represents its atomicity. A single molecule of phosphorus consists of four atoms, making it tetra-atomic. A molecule of sulphur contains eight atoms, which makes it an octa-atomic element.

2. Which of the following pairs correctly matches the element with its original Latin name?
(A) Sodium – Kalium
(B) Lead – Cuprum
(C) Tungsten – Wolfram
(D) Silver – Stibium

Ans : (C)

The symbol for tungsten is W, which is directly derived from its traditional German name Wolfram. The other metallic elements have entirely different linguistic origins silver is chemically known as Argentum, lead is Plumbum, and sodium is designated as Natrium.

3. The following table illustrates the relationship between the number of electrons in an atom's outermost shell (valence electrons) and its combining capacity (valency). An element 'Y' has 7 valence electrons. What is its valency?

Valence Electrons	1	2	3	4	5	6	7	8
Valency	1	2	3	4	3	2	1	0

(A) 7
(B) 1
(C) 2s
(D) 3

Ans : (B)

For atoms with more than four valence electrons, the valency is typically determined by the number of electrons needed to achieve a stable octet (8 electrons). An element with 7 valence electrons will gain one electron. Therefore, its valency is 8 - 7 = 1, as shown in the provided table.

4. Evaluate the following statements regarding the atomicity of elements and the nature of mixtures.
I. All noble gases have an atomicity of exactly one.
II. Sand mixed in water creates a completely homogeneous mixture.
III. Metallic elements like sodium and magnesium are purely monoatomic.
IV. Molecules of elements frequently contain dissimilar types of atoms.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

Ans : (B)

Noble gases and standard metals such as sodium are classified as monoatomic elements because they contain only one atom in their molecules. Sand in water visibly forms a heterogeneous mixture. Molecules of distinct elements always consist of precisely identical atoms.

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5. What does the chemical symbol of a specific element quantitatively represent?
(A) One molecule of the compound
(B) A mixture of varying atomic isotopes
(C) A definite mass of the element equal to its atomic mass
(D) The variable valency exhibited during diverse chemical reactions

Ans : (C)

A standard chemical symbol accurately represents a specific chemical element, exactly one distinct atom of that element, and a definite quantitative mass. This specific mass is mathematically equal to its established atomic mass when physically expressed in standard gram units.

6. **Assertion (A) :** Iron actively exhibits variable valencies of 2 and 3 in different chemical compounds.
Reason (R) : An atom can sometimes lose more electrons than those present in its valence shell by transferring electrons from the penultimate shell.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

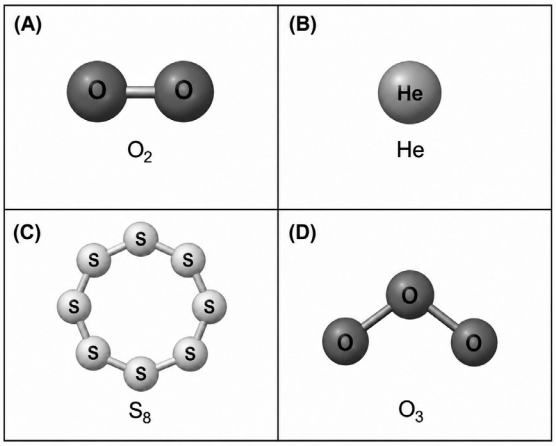
Iron frequently shows variable valency because it can energetically lose electrons from its outermost valence shell as well as its penultimate shell. This subsequent loss of additional internal electrons allows iron to successfully form both divalent and trivalent positive cations.

7. Applying the systematic rules of variable valency, what is the precise chemical formula for plumbic chloride?
(A) PbCl
(B) $PbCl_2$
(C) $PbCl_3$
(D) $PbCl_4$

Ans : (D)

Lead frequently exhibits variable combining capacity, specifically forming distinct divalent and tetravalent ions. The traditional suffix 'ic' fundamentally denotes the higher active valency state. Combining a tetravalent lead cation with a standard monovalent chloride anion yields the chemical formula $PbCl_4$.

8. The diagram shows models of molecules for four different substances. Which model represents an octa-atomic molecule?



(A) Model A
(B) Model B
(C) Model C
(D) Model D

Ans : (C)

Atomicity is the total number of atoms in one molecule. Model C represents Sulphur (S_8), which has eight atoms bonded together, making it octa-atomic. Model A (O_2) is diatomic, Model B (He) is monoatomic, and Model D (O_3) is triatomic. Therefore, Model C is the correct representation of an octa-atomic molecule.

9. Elements possessing exactly five, six, or seven electrons in their outermost electron shell are typically classified as
(A) Electropositive metals forming cations
(B) Electronegative non-metals forming anions
(C) Chemically inert noble gases
(D) Metalloids forming basic radicals

Ans : (B)

Elements possessing five, six, or seven outermost valence electrons chemically behave as non-metals. They inherently lack electronic stability and aggressively attract additional external electrons to complete their stable octet. This continuous electron gain logically transforms them into negatively charged anions.

10. Match the chemical radicals listed in List-I with their corresponding chemical formulas in List-II.
List-I (Type)
P. Ammonium
Q. Bicarbonate
R. Zincate
S. Plumbite

List-II (Type)

I. ZnO_2^{2-} →

II. NH_4^+ →

III. PbO_2^{2-} →

IV. HCO_3^- →

(A) P-II, Q-IV, R-I, S-III
(B) P-IV, Q-II, R-III, S-I
(C) P-II, Q-I, R-IV, S-III
(D) P-III, Q-IV, R-I, S-II

Ans : (A)

Ammonium acts as a purely monovalent electropositive radical. Bicarbonate serves as a monovalent electronegative radical. Both zincate and plumbite are rigorously classified as divalent electronegative compound radicals. These specific structural units independently carry distinct electrical charges during chemical reactions.

11. The modern symbols for some elements are derived from their non-English names. An analyst has compiled a list of such elements. According to the data, from which source name is the symbol 'K' for Potassium derived?

English Name	Symbol	Source Name
Sodium	Na	Natrium
Potassium	K	X
Silver	Ag	Argentum
Tungsten	W	Wolfram

(A) Krypton
(B) Kalium
(C) Cuprum
(D) Plumbum

Ans : (B)

The symbol 'K' for the element potassium originates from its Latin name, 'Kalium'. Similarly, 'Na' for sodium comes from 'Natrium' and 'Ag' for silver comes from 'Argentum'. 'Cuprum' is the Latin name for copper (Cu) and 'Plumbum' is for lead (Pb). 'Krypton' is a different element with the symbol Kr.

12. In the chemical formation of sodium chloride via neutralisation, why is the chloride ion specifically termed an acidic radical?

(A) It is directly contributed by the base sodium hydroxide

(B) It is directly contributed by hydrochloric acid

(C) It inherently carries a strong electropositive charge

(D) It actively neutralizes the salt's pH level

Ans : (B)

During a standard neutralisation reaction producing a salt, the required positively charged cation is fundamentally provided by the reacting base. Conversely, the negatively charged anion is strictly contributed by the participating acid, officially designating it as the active acidic radical.

13. Evaluate the following statements regarding the systematic naming of chemical compounds.

I. The prefix 'per' is strictly used when oxygen atoms are more than three.

II. The compound KClO is formally named potassium chlorate.

III. Binary acids are consistently named using the specific prefix 'hydro'.

IV. The suffix 'ous' indicates a higher number of oxygen atoms than 'ic'.

Which of the above statements are correct?

(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

Ans : (B)

Compounds containing more than three oxygen atoms consistently utilize the descriptive prefix 'per'. Potassium chlorate is chemically represented as $KClO_3$, not KClO. Furthermore, the classical suffix 'ous' logically indicates a relatively lower oxygen content when directly compared to the 'ic' suffix.

14. By mathematically analyzing the molecular formula of sulphur dioxide (SO_2), what is the calculated valency of sulphur?

(A) 2
(B) 3
(C) 4
(D) 6

Ans : (C)

The chemical valency of oxygen is conventionally taken as two. In a sulphur dioxide molecule, one single sulphur atom covalently bonds with two oxygen atoms. Multiplying the two oxygen atoms by their standard divalent capacity conclusively determines sulphur's valency as four.

15. The diagram shows the Bohr model of a neutral atom of element 'X', indicating its electronic

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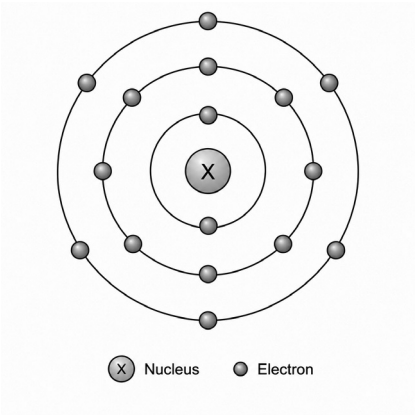
configuration. What is the valency of element X?



(A) 2
(B) 6
(C) 8
(D) 1

Ans : (A)

Valency is the combining capacity of an element. For non-metals with 5, 6, or 7 valence electrons, the valency is typically calculated as (8 - number of valence electrons). The atom shown has 6 valence electrons, so it will gain 2 electrons to achieve a stable octet. Therefore, its valency is 2.

16. Which of the following details is NOT inherently conveyed by a purely balanced skeletal chemical equation?

(A) The exact chemical composition of the respective reactant molecules
(B) The physical state of the participating solid, liquid, or gaseous substances
(C) The proportionate ratio of the relative molecular masses involved
(D) The strict proof validating the universal law of conservation of mass

Ans : (B)

A standard balanced chemical equation effectively communicates molecular compositions and proportional masses. However, unless specific state symbols are intentionally added to the formula, the foundational equation completely fails to provide any details regarding the physical states of the reacting substances.

17. When balancing the chemical decomposition reaction of lead nitrate, what is the precise numerical coefficient of nitrogen dioxide (NO_2)?

$$2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$$

(A) 2
(B) 3
(C) 4
(D) 6

Ans : (C)

Balancing chemical equations strictly requires accurately equalising specific atomic quantities on both the reactant and product sides. When exactly two molecules of lead nitrate thermally decompose, they structurally yield two molecules of lead oxide, four molecules of nitrogen dioxide, and one oxygen molecule.

18. An atom forms an ion to achieve a stable electron configuration, typically an octet, by either losing or gaining electrons. Analyze the data for the following elements. Which ion is correctly predicted for the element Magnesium (Mg)?

Element	Atomic Number	Electronic Configuration	Predicted Ion
Sodium (Na)	11	2, 8, 1	Na^+
Chlorine (Cl)	17	2, 8, 7	Cl^-
Magnesium (Mg)	12	2, 8, 2	Mg^{2+}
Oxygen (O)	8	2, 6	O^{2-}

(A) Mg^+
(B) Mg^{2+}
(C) Mg^{2-}
(D) Mg^{6-}

Ans : (B)

A magnesium atom has an electronic configuration of 2, 8, 2. To attain a stable octet configuration, it must lose the two electrons from its outermost shell. The loss of two negatively charged electrons results in the formation of a positive ion (cation) with a charge of +2. This ion is represented as Mg^{2+}.

19. By systematically utilizing the criss-cross method, determine the correct chemical formula for calcium phosphate.

(A) $CaPO_4$
(B) $Ca_2(PO_4)_3$
(C) $Ca_3(PO_4)_2$
(D) Ca_3P_2

Ans : (C)

To properly derive the correct chemical formula, the active valencies of the constituent radicals must be identified. Calcium functions as a divalent positive radical, while phosphate is a trivalent negative radical. Interchanging their

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fundamental valency numbers creates the formula $Ca_3(PO_4)_2$.

20. **Assertion (A) :** The accurate molecular formula for stable aluminium oxide is Al_2O_3.
Reason (R) : Aluminium functions as a trivalent electropositive radical, whereas oxygen behaves as a divalent electronegative radical.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Aluminium maintains a standard valency of three, meaning it consistently forms a trivalent cation. Oxygen holds a valency of two, forming a divalent anion. By accurately interchanging these specific valency numbers according to criss-cross rules, the precise formula becomes Al_2O_3.

21. A balanced chemical equation obeys the Law of Conservation of Mass. For the complete combustion of methane (CH_4), an experiment yields the following mass data. What mass of oxygen (O_2) was consumed in the reaction?
Equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Substance	Mass (g)
Methane (CH_4) reacted	16
Oxygen (O_2) reacted	X
Carbon Dioxide (CO_2) formed	44
Water (H_2O) formed	36

(A) 32 g
(B) 80 g
(C) 64 g
(D) 48 g

Ans : (C)

According to the Law of Conservation of Mass, the total mass of reactants equals the total mass of products. Total mass of products = 44 g (CO_2) + 36 g (H_2O) = 80 g. Therefore, the total mass of reactants must also be 80 g. The mass of oxygen (X) is 80 g - 16 g (CH_4) = 64 g.

22. Evaluate the following scientific statements regarding atomic mass measurement standards.
I. The unified atomic mass unit is universally designated by the symbol 'u'.
II. One atomic mass unit physically equals one-twelfth the mass of a Carbon-12 atom.
III. The absolute mass of a single Carbon-12 atom equals exactly 12.000 grams.
IV. Oxygen was previously utilized as an international standard before Carbon-12.
Which of the above statements are correct?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

The unified atomic mass unit effectively represents precisely one-twelfth of a stable Carbon-12 atom's mass. However, the absolute mass of a single Carbon-12 atom is exceedingly small, measuring approximately 1.9924 multiplied by 10-23 grams, strictly not twelve complete grams.

23. Calculate the exact relative molecular mass of ammonium sulphate, mathematically expressed as $(NH_4)_2SO_4$.
(Atomic masses N=14, H=1, S=32, O=16)
(A) 114 amu
(B) 128 amu
(C) 132 amu
(D) 146 amu

Ans : (C)

The total relative molecular mass involves summing all constituent atomic masses. For ammonium sulphate, the combined mathematical calculation strictly incorporates two nitrogen atoms, eight hydrogen atoms, one central sulphur atom, and four bonded oxygen atoms, accurately totalling exactly 132 amu.

24. Calculate the exact mass percentage of nitrogen chemically present in a standard urea molecule, mathematically expressed as NH_2CONH_2.
(Atomic masses N=14, C=12, O=16, H=1)
(A) 23.33%
(B) 36.50%
(C) 46.67%
(D) 53.33%

Ans : (C)

To determine the precise percentage of nitrogen in urea, divide the combined mass of both nitrogen atoms by the complete molecular mass, then multiply by one hundred. Since the total molecular mass is sixty, twenty-eight divided by sixty equals exactly 46.67%.

25. What does the empirical formula of a chemical compound fundamentally represent?
(A) The precise structural arrangement of atoms in a 3D molecule

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(B) The actual total number of varying atoms present in one complete molecule
(C) The simplest mathematical whole-number ratio of individual atoms in a molecule
(D) The absolute gram molecular mass of the entirely synthesized compound

Ans : (C)

(A) empirical formula scientifically expresses the simplest mathematically reduced whole-number ratio of constituent atoms within a specified chemical compound. Conversely, the accurate molecular formula illustrates the exact total quantity of individual atoms naturally present within a single stable molecule.

26. **Assertion (A) :** The determined empirical formula of standard hydrogen peroxide is formally written as HO.
Reason (R) : The empirical formula structurally represents the actual number of atoms of various elements actively present in one stable molecule.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The assertion remains chemically accurate because the mathematically simplified atomic ratio of hydrogen to oxygen in hydrogen peroxide is exactly one to one. However, the proposed reason is completely false because the molecular formula inherently determines the actual atomic count.

27. An unidentified organic hydrocarbon contains exactly 80% carbon by mass. What is the mathematically determined empirical formula of this compound?
(Atomic masses C=12, H=1)
(A) CH
(B) CH_2
(C) CH_3
(D) C_2H_3

Ans : (C)

To establish the precise empirical formula, divide the given percentage masses of carbon and hydrogen by their corresponding atomic masses. After dividing the resulting relative atomic values by the smallest calculated ratio, the simplified whole numbers strictly generate the empirical formula CH_3.

28. A chemical equation is a symbolic representation of a chemical reaction. In the equation provided, what does the symbol `(g)` written next to a substance indicate?

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

(A) The substance is a finely powdered solid.
(B) The substance is in the gaseous state.
(C) The substance is dissolved in water (aqueous).
(D) The substance is a catalyst for the reaction.

Ans : (B)

To make chemical equations more informative, the physical states of reactants and products are indicated by state symbols. The symbol `(g)` represents the gaseous state, `(l)` represents the liquid state, `(s)` represents the solid state, and `(aq)` represents an aqueous solution. The symbol `(g)` specifically indicates the substance is a gas.

29. The relative molecular mass (RMM) of a compound is the sum of the relative atomic masses (RAM) of its constituent atoms. Using the RAM values from the table, calculate the RMM of calcium phosphate, $Ca_3(PO^4)_2$.

Element	Symbol	Relative Atomic Mass (u)
Calcium	Ca	40
Phosphorus	P	31
Oxygen	O	16

(A) 135
(B) 215
(C) 279
(D) 310

Ans : (D)

The formula $Ca_3(PO^4)_2$ contains 3 Ca atoms, 2 P atoms, and 8 O atoms.
RMM = (3 × RAM of Ca) + 2 × (RAM of P + 4 × RAM of O)

$= (3 \times 40) + 2 \times (31 + (4 \times 16))$

$= 120 + 2 \times (31 + 64)$

$= 120 + 2 \times 95$

$= 120 + 190$

$= 310$ u.

30. If the experimentally measured vapour density of a specific organic compound is 45, what is its actual relative molecular mass?

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(A) 22.5
(B) 45
(C) 90
(D) 135

Ans : (C)

The experimentally calculated relative molecular mass of any stable volatile chemical compound exhibits a direct physical proportionality to its measured vapour density. Specifically, the accurate molecular mass is consistently calculated as exactly twice the scientifically determined vapour density value.

31. An ionic compound (salt) is formed from a basic radical (cation) and an acidic radical (anion). The table shows the constituent radicals of several compounds. Identify the basic and acidic radicals for Calcium Nitrate.

Compound Name	Formula	Basic Radical	Acidic Radical
Sodium Chloride	NaCl	Na^+	Cl^-
Calcium Nitrate	$Ca(NO_3)_2$	X	Y
Ammonium Sulphate	$(NH_4)_2SO_4$	NH_4^+	SO_4^{2-}

(A) X = Ca^{2+}, Y = NO_3^-
(B) X = Ca^{2+}, Y = N^{3-}
(C) X = NO_3^-, Y = Ca^{2+}
(D) X = Ca^+, Y = NO_3^{2-}

Ans : (A)

The basic radical is the cation, written first, and the acidic radical is the anion. In Calcium Nitrate, $Ca(NO_3)_2$, the basic radical is the calcium ion, which has a valency of 2 (Ca^{2+}). The acidic radical is the nitrate ion, which is a polyatomic anion with a charge of -1 (NO_3^-).

32. Match the metallic ions listed in List-I with their formal traditional chemical names in List-II.
List-I (Type)
P. Cu^+
Q. Cu_2^+
R. Fe_2^+
S. Fe_3^+
List-II (Type)
I. Cupric
II. Cuprous
III. Ferric
IV. Ferrous
(A) P-I, Q-II, R-IV, S-III
(B) P-II, Q-I, R-IV, S-III
(C) P-II, Q-I, R-III, S-IV
(D) P-I, Q-II, R-III, S-IV

Ans : (B)

Elements physically exhibiting variable valency traditionally utilize structural naming conventions where the specific suffix 'ous' formally denotes the comparatively lower valency state. Therefore, a monovalent copper cation is correctly termed cuprous, divalent is cupric, divalent iron is ferrous, and trivalent iron is ferric.

33. Which of the following chemically represents an explicitly defined simple basic radical?
(A) The negatively charged sulphate ion
(B) The positively charged ammonium ion
(C) The positively charged sodium ion
(D) The negatively charged bicarbonate ion

Ans : (C)

A basic simple radical consists exclusively of one single charged atom actively behaving as a chemical unit, accurately represented by the positively charged sodium ion. Conversely, the ammonium ion technically represents a multi-atom compound radical despite being distinctly electropositive.

34. Utilizing standard valency cross-referencing, what is the precise molecular formula for potassium dichromate?
(A) KCr_2O_7
(B) K_2CrO_4
(C) $K_2Cr_2O_7$
(D) $KCrO_4$

Ans : (C)

Potassium functions chemically as a standard monovalent electropositive radical, whereas dichromate behaves strictly as a divalent electronegative compound radical. By systematically executing the established criss-cross method to thoroughly balance the electrical charges, the chemically correct resulting formula clearly becomes $K_2Cr_2O_7$.

35. Evaluate the following statements regarding the conventional notation of chemical equations.
I. A basic skeletal equation inherently represents an electronically balanced chemical change.
II. Chemical equations must strictly satisfy the established universal law of conservation of mass.
III. An explicitly drawn upward arrow immediately following a product indicates an evolved gas.

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IV. A downward pointing arrow effectively indicates an insoluble solid precipitate formation.

Which of the above statements are correct?

(A) I, II, and III
(B) II, III, and IV
(C) I, III, and IV
(D) I, II, and IV

Ans : (B)

A skeletal chemical equation is inherently unbalanced and basically highlights the reacting participants and their corresponding generated products. Equations must forcefully be balanced to accurately satisfy the law of conservation of mass. Standard directional arrows efficiently denote gaseous emissions and solid precipitates.

36. Radicals are classified as simple (single atom) or compound (group of atoms acting as one unit). They also have a specific valency. Based on the information below, how would the Ammonium radical be classified?

Radical Name	Formula	Valency	Type
Chloride	Cl^-	1	Simple
Sulphate	SO^{42-}	2	Compound
Ammonium	NH^{4+}	1	Compound
Magnesium	Mg^{2+}	2	Simple

(A) A simple, monovalent radical
(B) A simple, divalent radical
(C) A compound, monovalent radical
(D) A compound, divalent radical

Ans : (C)

The ammonium radical has the formula NH^{4+}. Since it consists of a group of atoms (one nitrogen and four hydrogen) that behave as a single charged unit, it is a compound radical. The charge of 1+ indicates it has a valency of 1, making it monovalent. Therefore, it is a compound, monovalent radical.

37. How is an endothermic chemical reaction formally represented within a highly informative balanced chemical equation?

(A) By writing a specific plus sign alongside heat on the product side
(B) By explicitly putting a downward arrow directly beneath the reactants
(C) By placing a specific double-headed arrow between reacting molecules
(D) By writing a specific plus sign alongside heat on the reactant side

Ans : (D)

Endothermic chemical reactions forcefully absorb thermal energy directly from the external environment to successfully proceed. To communicate this particular energy requirement within a balanced equation, a distinct positive sign followed directly by heat is explicitly documented on the reactant side.

38. How many total protons and electrons mathematically exist within a stable trivalent aluminium cation (Al_3+)?
(Atomic number of Al = 1_3)

(A) 13 protons and 13 electrons
(B) 10 protons and 13 electrons
(C) 13 protons and 10 electrons
(D) 16 protons and 13 electrons

Ans : (C)

(A) electrically neutral standard aluminium atom intrinsically contains exactly thirteen protons and thirteen orbiting electrons. By systematically shedding its three reactive valence electrons to physically attain an electronically stable octet configuration, the newly formed trivalent cation retains its original thirteen protons.

39. **Assertion (A) :** The specifically written chemical equation $Cu + H_2SO_4 \longrightarrow CuSO_4 + H_2$ is fundamentally incorrect.
Reason (R) : Copper acts as a less chemically active metal than hydrogen and completely fails to displace it from standard acids.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The assertion correctly highlights an invalid reaction because copper fundamentally sits beneath hydrogen within the standard reactivity series. This comparably lower reactivity chemically prevents copper from successfully displacing bonded hydrogen directly from dilute acidic solutions to generate pure hydrogen gas.

40. Which of the following systematically named chemical radicals correctly exhibits a tetravalent electronegative charge?

(A) Silicate
(B) Aluminate
(C) Carbide
(D) Phosphide

Ans : (C)

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Chemical radicals are systematically categorized according to their specific combining valencies. While silicate is properly classified as a divalent radical and aluminate as trivalent, the purely non-metallic carbide radical structurally possesses a total negative charge of four, functioning perfectly as tetravalent.

41. A student tabulates the formulae of different substances to determine their atomicity, which is the total number of atoms in one molecule. Based on the data, what is the atomicity of a sulphur molecule?

Substance	**Formula**
Ozone	O_3
Phosphorus	P^4
Sulphur	S_8
Helium	He

(A) Two (diatomic)
(B) Four (tetra-atomic)
(C) One (mono atomic)
(D) Eight (octa-atomic)

Ans : (D)

Atomicity is the number of atoms present in one molecule of a substance. The chemical formula for a molecule of sulphur is S_8, which indicates it contains eight sulphur atoms. Therefore, its atomicity is eight, and it is classified as octa-atomic. Helium (He) is mono atomic, while ozone (O_8) is triatomic.

42. Calculate the precise relative molecular mass of a standard cane sugar molecule formally represented as $C_{12}H_{22}O_{11}$.
(Atomic masses C = 12, H = 1, O = 16)
(A) 180 amu
(B) 256 amu
(C) 342 amu
(D) 386 amu

Ans : (C)

The accurate relative molecular mass strictly equals the combined mathematical total of all bonded atomic masses. For cane sugar, sequentially multiplying the respective standard atomic weights of twelve carbons, twenty-two hydrogens, and eleven attached oxygens yields a final molecular mass of 342.

43. What is the calculated mass percentage of oxygen strictly contained within a molecule of sodium carbonate (Na_2CO_3)?
(Atomic masses Na = 23, C = 12, O = 16)
(A) 11.3%
(B) 43.4%
(C) 45.3%
(D) 56.6%

Ans : (C)

Accurately calculating the percentage composition strictly demands dividing the targeted element's entire mass by the overall molecular mass. In sodium carbonate, the three active oxygen atoms collectively contribute exactly forty-eight mass units. Dividing this by 106 yields a percentage of precisely 45.3%.

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44. When properly balancing the skeletal chemical equation $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$, what integer effectively serves as the coefficient for the water molecule?
(A) 2
(B) 3
(C) 4
(D) 8

Ans : (C)

Systematically balancing this specific skeletal equation strictly requires mathematically equalizing the constituent atoms present on both opposing sides. To successfully balance the four required oxygen atoms structurally present within the iron oxide product, a coefficient of exactly four must precede the water molecule.

45. Evaluate the following statements regarding the fundamental concept of chemical valency.

I. Elemental valency is standardly measured in terms of combining hydrogen or oxygen atoms.
II. Unreactive noble elements that completely fail to chemically combine consistently possess zero valency.
III. The calculated valency of an active transition element is frequently a distinct fractional number.
IV. The standard combining valency of a neutral carbon atom is universally recognized as exactly four.

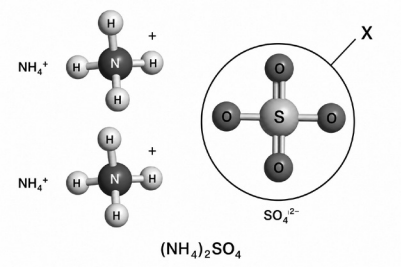
Which of the above statements are correct?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

Chemical valency fundamentally quantifies the precise combining capacity of an element, carefully measured using hydrogen or oxygen atoms. Noble gases strictly exhibit zero valency

because they remain entirely chemically inert. Furthermore, an element's structural valency must definitively be a whole integer.

46. The diagram shows the structure of a compound containing a polyatomic ion labelled 'X'. What is the name of the acidic radical represented by 'X'?



(A) Sulphide
(B) Sulphite
(C) Sulphate
(D) Bisulphate

Ans : (C)

The group labelled 'X' is the polyatomic ion SO_4^{2-}. This ion is derived from sulphuric acid (H_2SO_4) and is therefore an acidic radical. Its correct chemical name is the sulphate radical. Sulphide is S^{2-}, sulphite is SO_3^{2-}, and bisulphate is HSO^{4-}. Each has a different composition and charge.

47. By accurately applying proper valency interchange rules, identify the chemically correct molecular formula representing magnesium nitride.
(A) MgN
(B) Mg_2N_3
(C) Mg_3N_2
(D) MgN_2

Ans : (C)

A standard magnesium atom practically functions as a strong divalent electropositive radical, whereas the stable nitride ion distinctly acts as a trivalent electronegative radical. Applying the established criss-cross method correctly interchanges these exact valency values, predictably yielding the chemical formula Mg_3N_2.

48. If standard HNO_3 is universally named nitric acid, what is the technically correct nomenclature for the oxygen-deficient HNO_2 molecule?
(A) Hydronitric acid
(B) Nitrous acid
(C) Pernitric acid
(D) Nitride acid

Ans : (B)

Official chemical nomenclature standardly dictates that whenever a specific polyatomic radical holds relatively fewer bonded oxygen atoms, its corresponding resulting acid strictly uses the identifying suffix 'ous'. Consequently, while HNO_3 represents nitric acid, the specifically oxygen-deficient compound HNO_2 formally becomes nitrous acid.

49. **Assertion (A) :** A standard sodium atom forms a stable monovalent positive ion by deliberately gaining one external electron.
Reason (R) : Reactive atoms consistently lose or gain surrounding electrons to successfully attain a highly stable octet configuration internally.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

Although atoms actively exchange electrons to fundamentally secure a stable internal electronic configuration, sodium intrinsically operates as a strong electropositive metal. Consequently, it systematically sheds its single outermost valence electron rather than actively gaining one, predictably forming a stable monovalent positive cation.

50. Assuming oxygen holds a standard valency of two, what is the correctly calculated valency of nitrogen within the chemical compound N_2O_5?
(A) 2
(B) 3
(C) 4
(D) 5

Ans : (D)

The active chemical valency of distinct elements can be mathematically deduced straight from their specific molecular formulas. Assuming oxygen strictly maintains a standard valency of two, properly balancing the relative atomic ratios within the N_2O_5 molecule conclusively determines that nitrogen's valency is five.

51. Elements possessing exactly four electrons within their outermost orbital shell physically display highly varying metallic properties. Which of the following is strictly a non-metal?
(A) Silicon
(B) Germanium
(C) Carbon

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(D) Lead

Ans : (C)

Elements actively maintaining precisely four reactive valence electrons inherently display widely diverse physical characteristics. While silicon and structurally similar germanium are officially designated as semi-conducting metalloids, the universally occurring element carbon strictly and consistently behaves as a traditional non-metallic element chemically.

52. A student is balancing the equation for the reaction of copper with concentrated nitric acid. An intermediate step in the balancing process is shown in the table. To balance the Nitrogen (N) atoms, what coefficient must be placed before HNO_3?

Equation : $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$

Element	Atom Count (Reactants)	Atom Count (Products)
Cu	1	1
H	1	4
N	1	4 (2 in $Cu(NO_3)_2$ + 2 in NO_2)
O	3	10 (6 in $Cu(NO_3)_2$ + 2 in H_2O + 2 in NO_2)

(A) 1
(B) 2
(C) 3
(D) 4

Ans : (D)

The table shows that the product side has a total of 4 nitrogen atoms (2 from $Cu(NO_3)_2$ and 2 from $2NO_2$). The reactant side currently has only 1 nitrogen atom in HNO_3. To balance the nitrogen atoms, the number must be equal on both sides. Therefore, a coefficient of 4 must be placed before HNO_3.

53. Match the systematically named oxygen-based radicals listed in List-I with their accurate chemical formulas in List-II.

List-I (Type)
P. Hypochlorite
Q. Chlorate
R. Perchlorate
S. Chlorite

List-II (Type)
I. ClO_4^-
II. ClO_3^-
III. ClO_2^-
IV. ClO^-

(A) P-IV, Q-II, R-I, S-III
(B) P-IV, Q-III, R-I, S-II
(C) P-III, Q-II, R-I, S-IV
(D) P-I, Q-II, R-IV, S-III

Ans : (A)

Chemical nomenclature intentionally assigns descriptive prefixes and specific suffixes depending directly upon the variable quantity of oxygen atoms internally attached. The simple hypochlorite radical tightly holds one oxygen, chlorite securely contains two, chlorate predictably holds three, and perchlorate heavily bonds exactly four.

54. What fundamentally distinguishes the structurally formed molecule of a compound from the corresponding molecule of a pure element?

(A) A compound molecule strictly contains identical atoms combined covalently
(B) An element molecule inherently consists of dissimilar atoms chemically mixed
(C) A compound molecule systematically contains different atoms covalently combined in a fixed mathematical ratio
(D) An element molecule physically breaks down into heterogeneous multi-atom components upon heating

Ans : (C)

A critical scientific distinction dictates that the stable molecules of pure elements strictly comprise identical atoms securely bonded together. Conversely, the specific molecules of complex compounds systematically form whenever completely different elemental atoms covalently combine together in an absolute, universally fixed mathematical ratio.

55. Based strictly on the physical uniformity of their internal composition, how are salt dissolved in water and sand physically mixed in water classified respectively?

(A) Homogeneous mixture and heterogeneous mixture
(B) Heterogeneous mixture and homogeneous mixture
(C) Pure stable compound and heterogeneous mixture
(D) Homogeneous mixture and pure stable compound

Ans : (A)

Chemical mixtures are formally classified according to the visible physical uniformity

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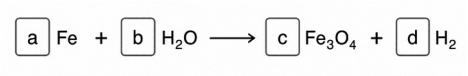
of their structural composition. Soluble salt completely dissolves in water, seamlessly yielding a physically uniform homogeneous mixture. Conversely, sand strictly remains insoluble, inevitably producing a visibly separated, phase-distinct heterogeneous liquid mixture.

56. The diagram shows a skeleton equation for the reaction between iron and steam. To satisfy the Law of Conservation of Mass, what are the correct stoichiometric coefficients (a, b, c, d) required to balance the equation?



(A) a=3, b=4, c=1, d=4
(B) a=1, b=2, c=1, d=2
(C) a=3, b=4, c=1, d=1
(D) a=2, b=3, c=1, d=3

Ans : (A)

To balance the equation, we match the number of atoms of each element on both sides. To balance Fe, c must be 1 and a must be 3. To balance O, b must be 4. This gives 8 H atoms on the left, so to balance H, d must be 4. The balanced equation is $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$.

57. Why do the recognized chemical symbols for select elements, such as Pb for lead and Ag for silver, appear completely unrelated to their modern English names?
(A) They strictly represent highly variable compound radicals rather than standard pure elements
(B) Their formal scientific abbreviations were specifically derived directly from classical Latin terminology
(C) Their distinct symbols solely reflect their respective atomic numbers on the periodic table
(D) They intentionally designate complex multivalent isotopic mixtures discovered by early ancient alchemists

Ans : (B)

In universally standard chemical nomenclature, several distinct elemental symbols trace their primary linguistic roots directly to classical Latin terminology rather than standard modern English vocabulary. For instance, the widely recognized abbreviation for lead is Pb, officially derived from its historical Latin designation, Plumbum.

58. When practically translating a descriptive chemical word equation into a symbolic formula, what are the specific reaction products of ammonium chloride physically heated with calcium hydroxide?
(A) Calcium chlorate, pure nitrogen gas, and pure water
(B) Calcium chloride, pure hydrogen gas, and standard ammonia
(C) Calcium chloride, pure ammonia gas, and pure water
(D) Pure calcium metal, nitrogen dioxide, and pure water

Ans : (C)

Properly translating a descriptive word equation directly into a balanced formal chemical equation demands accurately portraying every reacting substance. When solid ammonium chloride successfully reacts with heated calcium hydroxide, the ensuing chemical reaction reliably produces distinct molecules of calcium chloride, ammonia, and water.

59. What represents the correct standard chronological sequence strictly followed when determining the accurate empirical formula of a synthesized chemical compound?
I. Mathematically divide each relative atomic number by the lowest obtained value to establish a simple ratio.
II. Accurately calculate the percentage mass composition of each distinct element present.
III. Specifically write the individual chemical symbols alongside their numerically simplified subscript values.
IV. Systematically divide each element's percentage strictly by its established standard atomic mass.
(A) I, II, IV, III
(B) II, IV, I, III
(C) II, I, IV, III
(D) IV, II, I, III

Ans : (B)

Properly determining an accurate empirical formula demands a systematic mathematical sequence. One must strictly calculate elemental percentages first, then predictably determine the relative quantity of respective constituent atoms, sequentially find the mathematically simplest whole-number ratio, and carefully write the concluding chemical formula finally.

60. What specifically defines the universally accepted concept of an element's official gram atomic mass?

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(A) The combined relative mass of all existing isotopic variants expressed strictly in amu
(B) The measured absolute density of exactly one individual atom mathematically converted into volume
(C) The precisely calculated atomic mass of a designated element explicitly and formally expressed in grams
(D) The total mass of exactly one compound molecule divided sequentially by the carbon-12 benchmark

Ans : (C)

A standard atomic mass scientifically measures the precise relative weight of an individual atomic unit compared directly to standard carbon-12. When this exact mathematically calculated numerical value is practically weighed and strictly expressed in physical grams, it officially constitutes the element's gram atomic mass.

61. Which of the strictly categorized metallic groups listed below consists entirely of recognized electropositive trivalent radicals?
(A) Aluminium, Ferric iron, and Bismuth
(B) Calcium, Magnesium, and Zinc
(C) Sodium, Potassium, and Lithium
(D) Ferrous iron, Cupric copper, and Plumbous lead

Ans : (A)

Standard electropositive radicals act as metallic cations physically exhibiting positively charged states based precisely on their specifically lost outermost electrons. Elements like standard aluminium, ferric iron, and reactive bismuth systematically lose exactly three valence electrons, seamlessly functioning as active trivalent electropositive radicals chemically.

62. Why does a standard neutral nitrogen atom aggressively transform directly into a stable, negatively charged nitride anion within standard chemical environments?
(A) It naturally contains three valence electrons and completely loses them to attain stability
(B) It organically possesses five valence electrons and aggressively gains three more to complete its octet
(C) It systematically bonds with dissolved hydrogen to immediately form a stable electropositive monovalent radical
(D) It actively repels surrounding oxygen molecules to structurally maintain an overall neutral atomic valence

Ans : (B)

Non-metallic chemical elements naturally possessing precisely five outermost valence electrons inherently seek immediate internal electronic stability by completing their outermost atomic octet. Therefore, a standard nitrogen atom forcefully gains three surrounding electrons from available sources, effectively transforming into a highly stable trivalent nitride anion.

63. The empirical formula of a compound represents the simplest whole-number ratio of atoms of each element present. An analysis of an organic compound provided the data below. Determine its empirical formula.

Element	**Percentage Composition (%)**	**Atomic Mass (u)**
Carbon (C)	26.66	12
Hydrogen (H)	2.22	1
Oxygen (O)	71.12	16

(A) CHO
(B) $C_2H_2O^4$
(C) CHO_2
(D) CH_2O

Ans : (C)

To find the empirical formula, divide each percentage by the element's atomic mass to get a mole ratio. C: 26.66/12 ≈ 2.22; H: 2.22/1 = 2.22; O: 71.12/16 ≈ 4.44. Then, divide each value by the smallest result (2.22) to find the simplest whole-number ratio. C: 1, H: 1, O: 2. The empirical formula is therefore CHO_2.

64. In 1961, the International Union of Pure and Applied Chemistry (IUPAC) systematically adopted a critically important new foundational reference standard for calculating highly accurate relative atomic masses. What was this definitively adopted element?
(A) The naturally abundant radioactive isotope of oxygen-16
(B) The lightest existing monoatomic molecule of pure hydrogen gas
(C) The highly stable and predictable isotope of carbon-12
(D) The chemically inert and entirely non-reactive noble gas helium

Ans : (C)

Facing mounting scientific difficulties with previous oxygen-based measurement standards due directly to slightly varying distinct isotopes, the united scientific community systematically

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adopted a demonstrably superior physical benchmark. In 1961, IUPAC officially established the completely stable Carbon-12 isotope as the universal reference for calculating atomic masses.

65. Calculate the exact standard relative molecular mass of pure nitric acid, formally designated as HNO_3.
(Atomic masses H = 1, N = 14, O = 16)
(A) 45 amu
(B) 63 amu
(C) 74 amu
(D) 81 amu

Ans : (B)

The accepted relative molecular mass is strictly defined mathematically as the combined overall sum of the individual atomic masses of absolutely every element physically present. For specific nitric acid molecules, adding the masses of one hydrogen, one nitrogen, and three oxygens totals precisely sixty-three amu.

ONE MARK QUESTIONS

66. What is the reason behind using 'Na' as the symbol for Sodium instead of 'S'?

Ans :

Because 'Na' is derived from its Latin name 'Natrium', and 'S' is already reserved for Sulphur.

67. How is the symbol of an element written when two elements begin with the same alphabet?

Ans :

The first two letters of the name are used, where the first letter is capital and the second is small. Example: Ca for Calcium, Cl for Chlorine.

68. Give a reason why a chemical compound is always electrically neutral.

Ans :

The positive and negative valencies of the radicals in a compound always cancel each other, making the net charge zero.

69. Under what condition are brackets used in a chemical formula?

Ans :

Brackets are used when a polyatomic radical has a subscript greater than one, so that the subscript applies to the whole radical.

70. State the reason for choosing Carbon-12 as the standard unit for measuring atomic mass.

Ans :

Carbon-12 is stable, abundant, and gives accurate and consistent measurements, making it an ideal international standard.

71. Give a reason why certain elements show variable valency.

Ans :

Elements with incompletely filled inner shells can lose different numbers of electrons in different conditions, leading to variable valency.

72. How do we distinguish between two compounds of the same element having different valencies?

Ans :

By using suffixes — 'ic' for higher valency and 'ous' for lower valency. Example: Ferric (Fe^{3+}) and Ferrous (Fe^{2+}).

73. Give a reason why the prefix 'hydro' is not used while naming acids containing polyatomic radicals.

Ans :

The prefix 'hydro' is used only for binary acids (two elements). Acids with polyatomic radicals are named based on the radical, not the hydrogen.

74. How is the name of CO justified as carbon monoxide?

Ans :

Since CO contains one atom of oxygen and both elements are non-metals, the prefix 'mono' is used, giving the name carbon monoxide.

75. Give a reason why it is necessary to balance a chemical equation.

Ans :

To satisfy the Law of Conservation of Mass, which states that the total mass of reactants must equal the total mass of products.

76. How does the oxygen content of a compound decide the use of prefix 'per' in its name?

Ans :

The prefix 'per' is used when a compound contains more oxygen than the compound ending in '-ate'. Example: $NaClO_4$ (Sodium perchlorate) has more oxygen than $NaClO_3$.

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77. Give a reason why a chemical equation fails to indicate the rate of reaction.

Ans :

A chemical equation only represents reactants and products, giving no information about the speed or mechanism of the reaction.

78. How does Ammonium (NH_4^+) behave like a metallic radical despite containing no metal?

Ans :

Ammonium carries a positive charge and forms salts just like metal ions, so it is classified as a positive radical. Example: NH_4Cl.

79. Explain how valence electrons determine the valency of an element.

Ans :

Valency is the number of electrons lost, gained, or shared during bonding, which are always the valence electrons of the outermost shell.

80. How does the number of oxygen atoms decide whether an acid gets the suffix '-ic' or '-ous'?

Ans :

The acid with more oxygen gets the suffix '-ic' and the one with less oxygen gets '-ous'. Example: H_2SO_4 (sulphuric) and H_2SO_3 (sulphurous).

81. Explain why a single atom is never enclosed in brackets in a chemical formula.

Ans :

Brackets are meant for polyatomic radicals only. A single atom does not need brackets as the subscript applies to it directly.

82. How does the hit and trial method help in balancing a chemical equation?

Ans :

By assigning suitable coefficients to molecules by trial and error until the number of atoms of each element becomes equal on both sides.

83. Explain why hydrogen was replaced by Carbon-12 as the standard for measuring molecular mass.

Ans :

Carbon-12 gives more precise and internationally consistent results in modern mass spectrometry, making it a better reference than hydrogen.

84. How does the oxygen content of NaClO justify the prefix 'hypo' in its name?

Ans :

NaClO contains less oxygen than $NaClO_2$ (Sodium chlorite), so the prefix 'hypo' is used to indicate a lower level of oxygen.

85. Explain the importance of calculating percentage composition of a compound.

Ans :

It gives the proportion by mass of each element, which helps in finding the empirical formula and verifying the purity of a compound.

86. Some elements show variable valencies. Explain.

Ans :

Some elements show variable valencies because of the different electronic configuration. An atom of an element can sometimes lose more electrons than that are present in its valence shell, i.e. loss from the penultimate shell.

87. Account the disadvantages related with hit and trial method of balancing the equation.

Ans :

Following are the disadvantages:

(i) It takes a long time and a bit hectic.

(ii) It does not provide any information regarding the mechanism of reaction.

88. What is atomic mass unit?

Ans :

Atomic mass unit (amu) is equal to one twelfth ($1/12^{th}$) the mass of an atom of carbon whose atomic mass is 12.

89. What would be wrong, if we write CO for cobalt instead of Co?

Ans :

(C) represents carbon monoxide. For the symbol of element, the first letter should be capital and second should be small.

90. Why do elements exhibit variable valency.

Ans :

These elements not only lose electrons from the valence shell but also from the penultimate shell (second last shell).

DIRECTION : Fill in the blank

91. Fill in the blanks.

(i) Cl^-, F^- and CO_3^{2-} are _____ radicals.

(ii) Na^+ and Ca^{2+} + are _____ radicals.

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(iii) Symbol 'Hg' represents _____.
(iv) Chemical formula of carbon dioxide is _____.

Ans :
(i) acidic
(ii) basic
(iii) Mercury
(iv) CO_2

92. MN is a nitride of a metal M. Write down the formula of its
(i) sulphate (ii) hydroxide
(iii) oxide (iv) sulphide

Ans :
(i) $M_2(SO_4)_3$
(ii) $M(OH)_3$
(iii) M_2O_3
(iv) M_2S_3

93. Fill in the blanks:
(i) One atom of chlorine combines with one hydrogen atom to form a molecule of _____.
(ii) The positive ions are known as _____.
(iii) Carbon is denoted by the symbol _____ whereas copper is denoted by _____.
(iv) The valency of nitrogen in nitrogen dioxide, NO_2 is _____.
(v) Magnesium chloride has two radicals in which magnesium has _____ radical while chloride has _____ radical.

Ans :
(i) hydrogen chloride (ii) cations
(iii) C and Cu (iv) +4
(v) 1 and 2

94. Fill in the blanks.
(i) Positive radicals are called _____ radicals.
(ii) Negative radicals are called _____ radicals.
(iii) Chloride, Bromide and Iodide are _____ radicals.
(iv) Sulphuric acid contains _____ atoms of oxygen and sulphurous acid contains _____ atoms of oxygen.
(v) _____ radical is a basic radical although it is not a metal.

Ans :
(i) basic (ii) acidic (iii) acidic
(iv) four, three (v) Ammonium

95. Match the following:

	Chemical Name		**Formula**
(i)	Potassium hydrogen sulphate	(a)	$PbBr_2$
(ii)	Sodium sulphate	(b)	$ZnCO_3$
(iii)	Potassium sulphate	(c)	$KHSO_4$
(iv)	Zinc carbonate	(d)	Na_2SO_4
(v)	Lead [II] bromide	(e)	K_2SO_4

Ans :

	Chemical Name		**Formula**
(i)	Potassium hydrogen sulphate	(c)	$KHSO_4$
(ii)	Sodium sulphate	(d)	Na_2SO_4
(iii)	Potassium sulphate	(e)	K_2SO_4
(iv)	Zinc carbonate	(b)	$ZnCO_3$
(v)	Lead [II] bromide	(a)	$PbBr_2$

96. Match the following:

	Column I (Elements)		**Column II (Symbol)**
(i)	Acidic radicals	(a)	K^+, Na^+
(ii)	Basic radicals	(b)	Fe^{2+}, Fe^{3+}
(iii)	Monovalent radicals	(c)	CO_3^{2-}, SO_4^{2-}
(iv)	Variable valency	(d)	Cl^-, K^+
(v)	Tetravalent elements	(e)	Pb^{4+}, Pt^{4+}

Ans :

	Column I (Elements)		**Column II (Symbol)**
(i)	Acidic radicals	(c)	CO_3^{2-}, SO_4^{2-}
(ii)	Basic radicals	(a)	K^+, Na^+
(iii)	Monovalent radicals	(d)	Cl^-, K^+
(iv)	Variable valency	(b)	Fe^{2+}, Fe^{3+}
(v)	Tetravalent elements	(e)	Pb^{4+}, Pt^{4+}

97. Match the following:

	Column I (Elements)		**Column II (Symbol)**
(i)	Fluorine	(a)	Sc

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(ii)	Sodium	(b)	C
(iii)	Carbon	(c)	Xe
(iv)	Sulphur	(d)	Hg
(v)	Xenon	(e)	Cu
(vi)	Lead	(f)	F
(vii)	Mercury	(g)	Ti
(viii)	Copper	(h)	Pb
(ix)	Titanium	(i)	S
(x)	Scandium	(j)	Na

Ans :

	Column I (Elements)		**Column II (Symbol)**
(i)	Fluorine	(f)	F
(ii)	Sodium	(j)	Na
(iii)	Carbon	(b)	C
(iv)	Sulphur	(i)	S
(v)	Xenon	(c)	Xe
(vi)	Lead	(h)	Pb
(vii)	Mercury	(d)	Hg
(viii)	Copper	(e)	Cu
(ix)	Titanium	(g)	Ti
(x)	Scandium	(a)	Sc

98. Match the following:

	Column I (Name of the compounds)		**Column II (Formulae)**
(i)	Sodium hypochlorite	(a)	Na_2SO_4
(ii)	Sodium zincate	(b)	Na_2CO_3
(iii)	Sodium bicarbonate	(c)	$NaClO_3$
(iv)	Sodium silicate	(d)	$NaNO_2$
(v)	Sodium bisulphate	(e)	Na_2SiO_3
(vi)	Sodium nitrite	(f)	Na_2ZnO_2
(vii)	Sodium nitrate	(g)	NaClO
(viii)	Sodium sulphate	(h)	$NaHCO_3$
(ix)	Sodium chlorate	(i)	$NaHSO_4$
(x)	Sodium carbonate	(j)	$NaNO_3$

	Column I (Name of the compounds)		**Column II (Formulae)**
(i)	Sodium hypochlorite	(g)	NaClO
(ii)	Sodium zincate	(f)	Na_2ZnO_2
(iii)	Sodium bicarbonate	(h)	$NaHCO_3$
(iv)	Sodium silicate	(e)	Na_2SiO_3
(v)	Sodium bisulphate	(i)	$NaHSO_4$
(vi)	Sodium nitrite	(d)	$NaNO_2$
(vii)	Sodium nitrate	(j)	$NaNO_3$
(viii)	Sodium sulphate	(a)	Na_2SO_4
(ix)	Sodium chlorate	(c)	$NaClO_3$
(x)	Sodium carbonate	(b)	Na_2CO_3

Give the valency and the formula of the following radicals.

(i) Chlorate (ii) Oxalate
(iii) Stannate (iv) Zincate
(v) Cupric (vi) Silicate
(vii) Phosphate (viii) Nitride
(ix) Phosphide (x) Acetylide

Ans :

	Valency	**Formula**		**Valency**	**Formula**
(i)	1	ClO_3^{-1}	(ii)	2	$C_2O_4^{-2}$
(iii)	2	SnO_3^{-2}	(iv)	2	ZnO_2^{-2}
(v)	2	Cu^{2+}	(vi)	2	SiO_3^{-2}
(vii)	3	PO_4^{-3}	(viii)	3	N^{3-}
(ix)	3	P^{-3}	(x)	2	C_2^{-2}

99. Write the name of the following compounds:

(i) $Al_2(SO_4)_3$ (ii) KOH
(iii) Na_2PbO_2 (iv) HNO_3
(v) $Mg(HCO_3)_2$ (vi) $Mg(OH)_2$
(vii) KClO (viii) $Ca(OH)_2$
(ix) $(NH_4)_2S$ (x) H_2CO_3

Ans :

(i) Aluminium sulphate
(ii) Potassium hydroxide
(iii) Sodium plumbate
(iv) Nitric acid
(v) Magnesium bicarbonate
(vi) Magnesium hydroxide

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(vii) Potassium hypochlorite
(viii) Calcium hydroxide
(ix) Ammonium sulphide
(x) Carbonic acid

100. Determine the molecular mass of the following:
(i) $Al(OH)_3$ (ii) $PbCl_2$
(iii) CuO (iv) $KHSO_4$
(v) CaO (vi) NaCl

Ans :
(i) 27 + 48 + 3 = 78 amu
(ii) 207 + 71 = 278 amu
(iii) 63.5 + 16 = 79.5 amu
(iv) 39 + 1 + 32 + 64 = 136 amu
(v) 40 + 16 = 56 amu
(vi) 23 + 35.5 = 58.5 amu

101. Give the name of the following compounds?
(i) HNO_2 (ii) $Pb(NO_3)_2$
(iii) $KMnO_4$ (iv) H_2SO_3
(v) $NaHCO_3$ (vi) $(CH_3COO)_2Pb$
(vii) $CoCl_2$ (viii) $AlPO_4$

Ans :
(i) Nitrous acid
(ii) Lead nitrate
(iii) Potassium permanganate
(iv) Sulphurous acid
(v) Sodium bicarbonate
(vi) Lead acetate
(vii) Cobalt chloride
(viii) Aluminium phosphate

102. Copy and balance the following equations:
(i) $K_2Cr_2O_7 + HCl \longrightarrow KCl + CrCl_3 + H_2O + Cl_2$
(ii) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + H_2O + Cr_2O_3$
(iii) $Mg(NO_3)_2 \longrightarrow MgO + NO_2 + O_2$
(iv) $Hg(NO_3)_2 \longrightarrow Hg + NO_2 + O_2$
(v) $Na_2S_2O_3 + HCl \longrightarrow NaCl + H_2O + SO_2 + S$
(vi) $CaOCl_2 + NH_3 \longrightarrow CaCl_2 + H_2O + N_2$
(vii) $Al + Fe_2O_3 \longrightarrow Fe + Al_2O_3$
(viii) $NH_3 + O_2 \longrightarrow NO + H_2O$
(ix) $Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + H_2O + NO$
(x) $Mg + HNO_3 \longrightarrow Mg(NO_3)_2 + H_2O + NO_2$

Ans :
(i) $K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$
(ii) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + 4H_2O + Cr_2O_3$
(iii) $2Mg(NO_3)_2 \longrightarrow 2MgO + 4NO_2 + O_2$
(iv) $2Hg(NO_3)_2 \longrightarrow 2HgO + 4NO_2 + O_2$
(v) $Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2 + S$
(vi) $3CaOCl_2 + 2NH_3 \longrightarrow 3CaCl_2 + 3H_2O + N_2$
(vii) $2Al + Fe_2O_3 \longrightarrow 2Fe + Al_2O_3$
(viii) $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$
(viii) $3Zn + 8HNO_3 \longrightarrow 3Zn(NO_3)_2 + 4H_2O + 2NO$
(ix) $Mg + 4HNO_3 \longrightarrow Mg(NO_3)_2 + 2H_2O + 2NO_2$

TWO MARKS QUESTIONS

103. Write the chemical formulae of the following compounds using the criss-cross method:
(a) Magnesium chloride (b) Ferric oxide

Ans :
(a) Mg_2^+ and Cl^- interchange valencies = $MgCl_2$
(b) Fe_3^+ and O_2^- interchange valencies = Fe_2O_3

104. State two limitations of a chemical equation.

Ans :
A balanced chemical equation does not indicate the rate of the reaction, i.e., whether it is fast or slow.
It does not indicate the conditions like temperature, pressure, or concentration required for the reaction.

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105. Why should a chemical equation be always balanced?

Ans :
The chemical equation needs to be balanced so that it follows the law of conservation of mass. A balanced chemical equation occurs when the number of different atoms of elements in the reactants side is equal to that of the products side.

106. A student writes the symbol of Calcium as CA. Is it correct? Give a reason.

Ans :
No.
(i) The first letter should be capital and the second letter should be small.
(ii) The correct symbol is Ca.

107. Why can the symbol 'C' represent both an element and an atom?

Ans :
(i) Qualitatively, it represents the element Carbon.
(ii) Quantitatively, it represents one atom of Carbon.

108. An atom has the electronic configuration 2,8,1. What is its valency? Explain.

Ans :

(i) It has one valence electron.
(ii) It can lose one electron, so its valency is 1.

109. Why is the valency of oxygen 2 although it has 6 valence electrons?

Ans :

(i) Oxygen needs 2 more electrons to complete its octet.
(ii) Therefore, its valency is 2.

110. Iron exhibits variable valency. What is meant by this term?

Ans :

(i) Variable valency means showing more than one valency.
(ii) Iron shows +2 (Ferrous) and +3 (Ferric) valencies.

111. Why is NH_4^+ called a radical even though it contains more than one atom?

Ans :

(i) It is a group of atoms.
(ii) It behaves as a single unit during chemical reactions.

112. A compound contains calcium ions and chloride ions. Why must two chloride ions combine with one calcium ion?

Ans :

(i) Calcium has valency +2.
(ii) Chloride has valency –1, therefore two chloride ions are needed to make the compound neutral.

113. Why is a chemical compound always electrically neutral?

Ans :

(i) Total positive charge equals total negative charge.
(ii) The net charge becomes zero.

114. A student writes the formula of magnesium chloride as MgCl. Identify the error.

Ans :

(i) Magnesium has valency 2 and chlorine has valency 1.
(ii) The correct formula is $MgCl_2$.

115. Why are brackets used in $Ca(OH)_2$ but not in CaO?

Ans :

(i) OH is a polyatomic radical.
(ii) Since it occurs twice, brackets are required around OH.

116. Why is CO named carbon monoxide while CO_2 is named carbon dioxide?

Ans :

(i) CO contains one oxygen atom, so the prefix "mono" is used.
(ii) CO_2 contains two oxygen atoms, so the prefix "di" is used.

117. Why is Na_2SO_4 called sodium sulphate and not sodium sulphite?

Ans :

(i) Sulphate contains more oxygen atoms than sulphite.
(ii) Therefore Na_2SO_4 is sodium sulphate.

118. What is the difference between sodium chlorate and sodium perchlorate?

Ans :

(i) Sodium perchlorate contains more oxygen atoms.
(ii) Therefore the prefix "per" is used.

119. Why is HCl called hydrochloric acid but HNO_3 called nitric acid?

Ans :

(i) HCl is a binary acid, so the prefix "hydro" is used.
(ii) HNO_3 contains a polyatomic radical (nitrate), so "hydro" is not used.

120. Why is NaOH classified as a base?

Ans :

(i) It is a metallic hydroxide.
(ii) Metallic hydroxides are bases.

121. In the equation $Mg + 2HCl \rightarrow MgCl_2 + H_2$, identify the reactants and products.

Ans :

(i) Reactants: Mg and HCl.
(ii) Products: $MgCl_2$ and H_2.

122. Why is a balanced chemical equation important?

Ans :

(i) It obeys the law of conservation of mass.
(ii) The number of atoms of each element is equal on both sides.

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123. A student says that the equation $H_2 + Cl_2 \rightarrow HCl$ is balanced. Is the statement correct?

Ans :

No.

(i) There are two hydrogen atoms and two chlorine atoms on the left.

(ii) The balanced equation is $H_2 + Cl_2 \rightarrow 2HCl$.

124. State one limitation of a chemical equation.

Ans :

(i) It does not indicate whether the reaction is fast or slow.

(ii) It also does not show reaction conditions.

125. A balanced equation shows that 24 g of magnesium reacts with 98 g of sulphuric acid. What important law does this verify?

Ans :

(i) Law of Conservation of Mass.

(ii) Total mass of reactants equals total mass of products.

126. Write symbol for

(i) Gold (ii) lead

(iii) Mercury (iv) Silver

Ans :

(i) Au (ii) Pb

(iii) Hg (iv) Ag

127. Why do we use symbol P for phosphorus but K for potassium?

Ans :

In the case of phosphorus, first letter of the element is taken as its symbol and it is written as capital, whereas in case of potassium, the symbol of the element has been derived from the latin name, Kalium.

128. How are compounds named when they contain two non-metals? Give two examples.

Ans :

When a compound contains two non-metals, prefixes like mono, di, tri, etc. are used to indicate the number of atoms.

CO = Carbon monoxide (one oxygen atom)

PCl_5 = Phosphorus pentachloride (five chlorine atoms)

129. What is the difference between atomic mass and gram atomic mass?

Ans :

Atomic mass – It is the number which represents how many times an atom of an element is heavier than 1/12th of the mass of Carbon-12 atom.

Gram atomic mass – When the relative atomic mass of an element is expressed in grams, it is called gram atomic mass.

Example: Gram atomic mass of Oxygen = 16g.

130. Distinguish between basic radicals and acidic radicals with one example each.

Ans :

Basic radicals (cations) – These are positively charged radicals formed by loss of electrons. Example: Ca^{2+} (Calcium ion).

Acidic radicals (anions) – These are negatively charged radicals formed by gain of electrons. Example: SO_4^{2-} (Sulphate ion).

131. State two differences between a reactant and a product in a chemical equation.

Ans :

Reactant – Written on the left side of the arrow. These are substances that take part in the reaction.

Product – Written on the right side of the arrow. These are substances that are formed as a result of the reaction.

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132. Explain with example how the prefix 'hypo' and 'per' are used in naming compounds.

Ans :

Hypo – Used when oxygen content is less than the compound ending in '-ite'. Example: $NaClO$ = Sodium hypochlorite (less oxygen than $NaClO_2$).

Per – Used when oxygen content is more than the compound ending in '-ate'. Example: $NaClO_4$ = Sodium perchlorate (more oxygen than $NaClO_3$).

133. How are acids named? Give two examples each of binary acids and acids with polyatomic radicals.

Ans :

Binary acids – Prefix 'hydro' and suffix '-ic' is added to the non-metal name.

HCl = Hydrochloric acid

HBr = Hydrobromic acid

Acids with polyatomic radicals – Named based on the radical, without 'hydro'.

H_2SO_4 = Sulphuric acid

HNO_3 = Nitric acid

134. What information does a balanced chemical equation convey about mass? Explain with an example.

Ans :

A balanced chemical equation tells us the exact masses of reactants and products involved in the reaction.
Example: $Mg + H_2SO_4 = MgSO_4 + H_2$
This tells us that 24g of Mg reacts with 98g of H_2SO_4 to form 120g of $MgSO_4$ and 2g of H_2, satisfying the Law of Conservation of Mass.

135. What do the following symbols stand for

(i) H (ii) H_2
(iii) 2H (iv) $2H_2$

Ans :

(i) Hydrogen atom
(ii) Hydrogen molecule
(iii) 2 atoms of hydrogen
(iv) Two molecules of hydrogen

136. Give the chemical name of the following compounds:

(i) NaClO (ii) $NaClO_3$
(iii) $NaClO_2$ (iv) $NaClO_4$

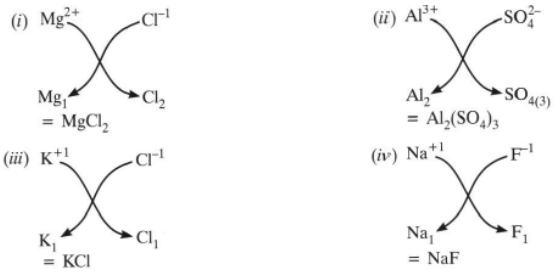
Ans :

(i) Sodium hypochlorite
(ii) Sodium chlorate
(iii) Sodium chlorite
(iv) Sodium perchlorate

137. Write the chemical formulae by criss cross method.

(i) Magnesium chloride
(ii) Aluminium sulphate
(iii) Potassium chloride
(iv) Sodium fluoride

Ans :



138. What do you understand by polyatomic ions? Give example to support your answer.

Ans :

The prefix poly means many. So, a polyatomic ion is an ion which contains more than one atom.
Example:
(i) Ammonium ion (NH_4^+)
(ii) Hydrogen sulphate ion (HSO_4^-)
(iii) Nitrate ion (NO_3^-)
(iv) Hydroxide ion (OH^-)

139. What is a symbol? What is its significance?

Ans :

A symbol is a short form that represents an atom of a specific element.
Significance of a Symbol:
(i) A symbol represents the name of the element.
(ii) It represents one atom of the element.
(iii) It represents the relative atomic mass of the element.

140. What is percentage composition? Calculate the percentage of hydrogen in H_2O. (H=1, O=16)

Ans :

The percentage by weight of each element present in a molecule of a compound is called percentage composition.

Molecular mass of $H_2O = 2(1) + 16$
$= 18$

Percentage of Hydrogen $= (2 / 18) \times 100$
$= 11.1\%$

141. Arrange the given elements in the decreasing order of their valencies:
Potassium, Calcium, Argon, Silicon, Phosphorus.

Ans :

Valencies of Potassium = 1, Calcium = 2
Argon = 0, Silicon = 4
and Phosphorus = 3
Decreasing order is
Silicon > Phosphorus > Calcium
> Potassium > Argon.

142. Differentiate between skeleton and balanced chemical equations.

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Ans :

Skeleton chemical equation	Balanced chemical equation
It simply represents the symbols and formulae of substances taking part in a reaction.	In this equation, the number of atoms of each element are equal on both sides of the equation.
Example: $CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$	Example: $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

THREE MARKS QUESTIONS

143. A student writes the symbols of sodium, sulphur and silver as So, SU and SI respectively. Identify the mistakes and write the correct symbols.

Ans :

(i) Sodium → Na
(ii) Sulphur → S
(iii) Silver → Ag

144. An element X has electronic configuration 2,8,3.
(a) How many valence electrons does it have?
(b) What is its valency?
(c) Will it form a positive or negative ion?

Ans :

(a) 3 valence electrons
(b) Valency = 3
(c) It will form a positive ion by losing 3 electrons.

145. Explain why Iron is represented as Fe and not Ir.

Ans :

(i) Fe is derived from the Latin name *Ferrum*.
(ii) Ir is the symbol of Iridium.
(iii) Therefore Iron is represented by Fe.

146. A compound contains aluminium and oxygen.
(a) State the valencies of aluminium and oxygen.
(b) Write the formula of the compound.
(c) Name the compound.

Ans :

(a) Aluminium = 3, Oxygen = 2
(b) Al_2O_3
(c) Aluminium oxide

147. Differentiate between a symbol and a formula.

Ans :

(i) A symbol represents an element.
(ii) A formula represents a molecule or compound.
(iii) Example: O is a symbol whereas H_2O is a formula.

148. Why is $Ca(OH)_2$ written with brackets whereas $CaCl_2$ is written without brackets?

Ans :

(i) OH is a polyatomic radical.
(ii) Two hydroxide radicals are present in the compound.
(iii) Therefore brackets are used around OH.

149. Write the formulae of the following compounds and name them:
(a) Calcium + Chloride
(b) Aluminium + Sulphate

Ans :

(a) $CaCl_2$ – Calcium chloride
(b) $Al_2(SO_4)_3$ – Aluminium sulphate

150. A student writes NH_4SO_4 as the formula of ammonium sulphate. Explain the error.

Ans :

(i) Ammonium has valency 1.
(ii) Sulphate has valency 2.
(iii) Correct formula is $(NH_4)_2SO_4$.

151. Explain the significance of a chemical formula using H_2SO_4.

Ans :

(i) It represents sulphuric acid.
(ii) It contains 2 hydrogen, 1 sulphur and 4 oxygen atoms.
(iii) It gives the composition of the molecule.

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152. Why is KNO_2 called potassium nitrite while KNO_3 is called potassium nitrate?

Ans :

(i) Nitrate contains more oxygen atoms than nitrite.
(ii) KNO_2 contains less oxygen.
(iii) Therefore KNO_2 is called potassium nitrite.

153. Write the names of the following compounds:
(a) Na_2CO_3
(b) CuO
(c) $FeCl_3$

Ans :

(a) Sodium carbonate
(b) Copper oxide
(c) Ferric chloride

154. A student writes $H_2 + O_2 \rightarrow H_2O$.
(a) Is the equation balanced?
(b) If not, write the balanced equation.
(c) Why must equations be balanced?

Ans :

(a) No.
(b) $2H_2 + O_2 \rightarrow 2H_2O$
(c) To obey the law of conservation of mass.

155. State any three pieces of information conveyed by a balanced chemical equation.

Ans :

(i) Reactants taking part in the reaction.
(ii) Products formed in the reaction.
(iii) Number of molecules and atoms involved.

156. A compound contains sodium and oxygen.
(a) Write its formula.
(b) Name the compound.
(c) Explain how the formula is obtained.

Ans :

(a) Na_2O
(b) Sodium oxide
(c) Sodium has valency 1 and oxygen has valency 2; criss-crossing gives Na_2O.

157. Why is H_2SO_4 called sulphuric acid while H_2SO_3 is called sulphurous acid?

Ans :

(i) H_2SO_4 contains more oxygen atoms.
(ii) H_2SO_3 contains fewer oxygen atoms.
(iii) Therefore H_2SO_4 is sulphuric acid and H_2SO_3 is sulphurous acid.

158. Explain why $Mg + HCl \rightarrow MgCl_2 + H_2$ is not a balanced equation.

Ans :

(i) Chlorine atoms are unequal on both sides.
(ii) Hydrogen atoms are also unequal.
(iii) Balanced equation is $Mg + 2HCl \rightarrow MgCl_2 + H_2$.

159. A radical X has valency –1 and combines with calcium.
(a) What is the valency of calcium?
(b) What will be the formula of the compound?
(c) Why?

Ans :

(a) Calcium has valency 2.
(b) CaX_2
(c) Two X radicals are required to balance the +2 charge of calcium.

160. Explain the difference between ferrous chloride and ferric chloride.

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Ans :

(i) Ferrous chloride contains Fe^{2+} ions.
(ii) Ferric chloride contains Fe^{3+} ions.
(iii) Iron shows variable valency.

161. A student says that a balanced equation tells whether a reaction is fast or slow. Do you agree? Give reasons.

Ans :

(i) No.
(ii) A balanced equation does not indicate the rate of reaction.
(iii) It only shows the relationship between reactants and products.

162. Why is $Al_2(SO_4)_3$ electrically neutral?

Ans :

(i) Aluminium has a charge of +3.
(ii) Sulphate has a charge of –2.
(iii) Total positive charge (+6) equals total negative charge (–6), making the compound neutral.

163. The valency of metal 'M' is +3. Give the formula of its

(i) chloride	(ii) hydroxide
(iii) sulphide	(iv) nitrate
(v) sulphate	(vi) phosphate

Ans :

(i) MCl_3	(ii) $M(OH)_3$
(iii) M_2S_3	(iv) $M(NO_3)_3$
(v) $M_2(SO_4)_3$	(vi) MPO_4

164. "A balanced equation does not tell whether heat energy, light energy, pressure, catalyst, etc. are required in a balanced equation".
How is this limitation overcome in a balanced equation.

Ans :

The problem was partly solved by writing the conditions of reaction on the arrow head. For example,

$$N_2(g) + 3H_2(g) \xrightleftharpoons[900\,atm - 450^\circ C]{Fe,\,Mo} 2NH_3(g)$$

From the given equation we can conclude that 1 volume of nitrogen gas reacts with 3 volume of hydrogen gas under a pressure of 900 atm and at a temperature of 450°C. This reversible reaction takes place in the presence of iron, acting as catalyst and molybdenum, acting as a promoter, 2 Volume of ammonia gas is formed.

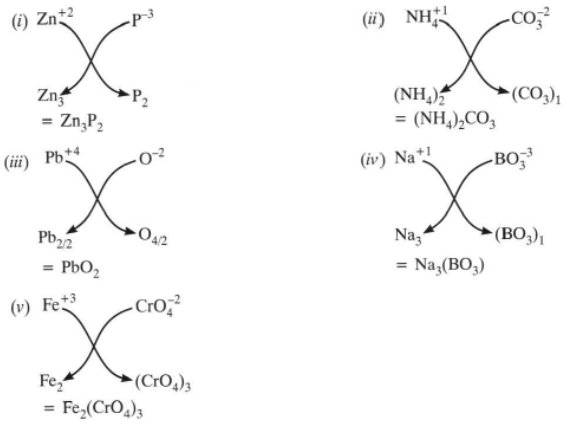
165. Define variable valency with two examples.

Ans :

Certain elements exhibit more than one valency by losing electrons present in the penultimate shell. Such valency is called variable valency.
If the element has two different positive valencies, then suffix-ic' is attached at the end of the name of the metal for the higher valency and suffix-'ous' is attached at the end of the name of the metal for the lower valency. For example, Lead (Plumbum) exhibits two valencies +2 and +4. The lower valency of lead (Pb^{2+}) is named as plumbous. The higher valency of lead (Pb^{4+}) is named as plumbic.

166. Deduce the molecular formula for the following compounds:
(i) Zinc phosphide
(ii) Ammonium carbonate
(iii) Lead (IV) oxide
(iv) Sodium Borate
(v) Ferric chromate

Ans :


(i) Zn^{+2} P^{-3} Zn_3 P_2 = Zn_3P_2
(ii) NH_4^{+1} CO_3^{-2} $(NH_4)_2$ $(CO_3)_1$ = $(NH_4)_2CO_3$
(iii) Pb^{+4} O^{-2} $Pb_{2/2}$ $O_{4/2}$ = PbO_2
(iv) Na^{+1} BO_3^{-3} Na_3 $(BO_3)_1$ = $Na_3(BO_3)$
(v) Fe^{+3} CrO_4^{-2} Fe_2 $(CrO_4)_3$ = $Fe_2(CrO_4)_3$

FOUR MARKS QUESTIONS

167. An element X has the electronic configuration 2,8,7.
(a) How many valence electrons does it have?
(b) What is its valency?
(c) Will it form a positive or negative ion?
(d) Give one reason for your answer.

Ans :
(a) 7 valence electrons
(b) Valency = 1
(c) Negative ion
(d) It gains one electron to complete its octet.

168. Differentiate between a symbol and a chemical formula with two examples of each.

Ans :

Symbol	**Chemical Formula**
Represents an element	Represents a molecule/ compound
Represents one atom	Represents the number of atoms in a molecule
Examples: H, O	Examples: H_2O, CO_2
Short form of an element	Symbolic representation of a compound

169. Explain the criss-cross method by writing the formula of Aluminium Sulphate.

Ans :
(i) Aluminium = Al^{3+}
(ii) Sulphate = SO_4^{2-}
(iii) Criss-cross the valencies → $Al_2(SO_4)_3$
(iv) Formula = $Al_2(SO_4)_3$

170. Write the formulae and names of the following compounds:
(a) Calcium + Nitrate
(b) Magnesium + Hydroxide
(c) Aluminium + Chloride
(d) Sodium + Carbonate

Ans :
(a) $Ca(NO_3)_2$ – Calcium nitrate
(b) $Mg(OH)_2$ – Magnesium hydroxide
(c) $AlCl_3$ – Aluminium chloride
(d) Na_2CO_3 – Sodium carbonate

171. Explain the term "variable valency" with the example of iron.

Ans :
(i) Some elements show more than one valency.
(ii) This property is called variable valency.
(iii) Iron shows +2 and +3 valencies.
(iv) Fe^{2+} is called ferrous and Fe^{3+} is called ferric.

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172. State four significances of a chemical formula.

Ans :

(i) It represents the name of the compound.
(ii) It shows the number of atoms present.
(iii) It gives the molecular mass of the compound.
(iv) It indicates the ratio of elements present.

173. A student writes the formula of calcium phosphate as $CaPO_4$.
(a) Is it correct?
(b) Write the correct formula.
(c) State the valencies used.
(d) Name the compound.

Ans :

(a) No.
(b) $Ca_3(PO_4)_2$
(c) Calcium = 2, Phosphate = 3
(d) Calcium phosphate

174. Explain how the names of the following compounds are derived:
(a) Na_2SO_3
(b) Na_2SO_4
(c) KNO_2
(d) KNO_3

Ans :

(i) Na_2SO_3 – Sodium sulphite (less oxygen)
(ii) Na_2SO_4 – Sodium sulphate (more oxygen)
(iii) KNO_2 – Potassium nitrite (less oxygen)
(iv) KNO_3 – Potassium nitrate (more oxygen)

175. State any four pieces of information conveyed by a balanced chemical equation.

Ans :

(i) Reactants taking part in the reaction.
(ii) Products formed in the reaction.
(iii) Number of atoms and molecules involved.
(iv) Relative masses of reactants and products.

176. Balance the following equation and show the atom count:
$Mg + HCl \rightarrow MgCl_2 + H_2$

Ans :

Balanced equation:
$Mg + 2HCl \rightarrow MgCl_2 + H_2$
Atom count:

Mg = 1 on both sides

H = 2 on both sides

Cl = 2 on both sides

Therefore, the equation is balanced.

177. Explain why $Al(OH)_3$ is written with brackets while Al_2O_3 is not.

Ans :

(i) OH is a polyatomic radical.
(ii) Three hydroxide radicals are present.
(iii) Therefore brackets are required around OH.
(iv) Oxygen is a single atom, so brackets are not needed in Al_2O_3.

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178. Write the names of the following compounds and identify whether they are acids, bases or salts:
(a) HCl
(b) NaOH
(c) NaCl
(d) H_2SO_4

Ans :

(a) Hydrochloric acid – Acid
(b) Sodium hydroxide – Base
(c) Sodium chloride – Salt
(d) Sulphuric acid – Acid

179. A compound contains aluminium ions and sulphate ions.
(a) Write the symbols of the ions.
(b) State their valencies.
(c) Write the formula of the compound.
(d) Name the compound.

Ans :

(a) Al^{3+} and SO_4^{2-}
(b) Valencies = 3 and 2
(c) $Al_2(SO_4)_3$
(d) Aluminium sulphate

180. Explain any four limitations of a chemical equation.

Ans :

(i) It does not indicate the rate of reaction.
(ii) It does not show reaction conditions.
(iii) It does not indicate physical states of substances.
(iv) It does not show whether heat is evolved or absorbed.

181. A balanced equation shows:
$24\ g\ Mg + 98\ g\ H_2SO_4 \rightarrow 120\ g\ MgSO_4 + 2\ g\ H_2$
What conclusions can you draw from this equation?

Ans :

(i) Magnesium reacts with sulphuric acid.
(ii) Magnesium sulphate and hydrogen are formed.

(iii) Total mass of reactants equals total mass of products.
(iv) The equation obeys the Law of Conservation of Mass.

182. Define the following:
(i) Valency
(ii) Chemical equation
(iii) Atomic mass unit
(iv) Radicals.

Ans :

(i) Valency: The valency of an element or a radical is defined as the number of hydrogen atoms that combine or displace one atom of that element or radical. In other words, valency is defined as the number of electrons, which an atom can gain/lose/ share in a chemical reaction.

(ii) Chemical equation: The symbolic representation of a chemical reaction using symbols and formula of the elements is called chemical equation. For example, $C + O_2 \xrightarrow{\Delta} CO_2$ is the chemical equation. Its word equation is as follows:

$$\text{Carbon} + \text{Oxygen} \xrightarrow{\text{Heat}} \text{Carbon dioxide}$$

(iii) Atomic mass unit (amu): It is defined as the mass of $1/12^{\text{th}}$ of carbon atom whose mass is 12. For example, mass of oxygen is 16 amu and hydrogen is 1 amu.

(iv) Radicals: A radical is an atom or group of atoms which does not exist independently but behave as a single unit with a positive or negative ion. For example, in $(NH_4)_2CO_3$, NH_4^+ is a basic radical, whereas CO_3^{2-} is an acidic radical.

NUMERICAL QUESTIONS

183. Find the total percentage of Oxygen in Magnesium Nitrate $[Mg(NO_3)_2.6H_2O]$ crystal. (H = 1, N = 14, O = 16, Mg = 24)

Ans :

Molecular weight of $Mg(NO_3)_2.6H_2O$

$$= 24 + 2 \times (14 + 48) + 6 \times 18$$
$$= 24 + 2 \times 62 + 108$$
$$= 24 + 124 + 108 = 256 \text{ g}$$

Weight of Oxygen

$$= 12 \times 16 = 192 \text{ g}$$

$$\% \text{ of Oxygen} = \frac{192}{256} \times 100\% = 75\% \text{ of Oxygen}$$

184. Calculate the percentage of nitrogen and oxygen in ammonium nitrate. [Relative molecular mass of ammonium nitrate is 80, H = 1, N = 14, O = 16].

Ans :

Molecular mass of ammonium nitrate $[NH_4NO_3]$

$$= 14 + 4 + 14 + 48 = 80 \text{ g}$$

$$\% \text{ of N} = \frac{28}{80} \times 100 = 35\%$$

$$\% \text{ of O} = \frac{48}{80} \times 100 = 60\%$$

185. Find the total percentage of Magnesium in magnesium nitrate crystals, $Mg(NO_3)_2.6H_2O$. [Mg = 24; N = 14; O = 16 and H = 1]

Ans :

Molecular weight of $Mg(NO_3)_2.6H_2O$

$$= 24 + 2 \times (14 + 48) + 6 \times 18$$
$$= 24 + 2 \times 62 + 108$$
$$= 24 + 124 + 108 = 256 \text{ g}$$

% composition of Mg

$$= \frac{24 \times 100}{256} = 9.375\%$$

186. Calculate the relative molecular masses of
(i) Hydrated calcium chloride $(CaCl_2.6H_2O)$
(ii) Fructose $(C_6H_{12}O_6)$.

Ans :

(i) Molecular mass of $CaCl_2.6H_2O$

$$= 1 \times 40 + 2 \times 35.5 + 6 \times (1 \times 2 + 16)$$
$$= 40 + 71 + 6 \times 18 = 219 \text{ amu}$$

Relative molecular mass of $CaCl_2.6H_2O = 219$ amu

(ii) Molecular mass of Fructose $(C_6H_{12}O_6)$

$$= 6 \times 12 + 12 \times 1 + 6 \times 16$$
$$= 72 + 12 + 96 = 180 \text{ amu}$$

Relative molecular mass = 180 amu

187. Calculate the percentage of underlined elements in the following compounds: (H = 1, C = 12, N = 14, O = 16, B = 11, Na = 23, Pt = 195)
(i) $(NH_4)_2\underline{Pt}Cl_6$
(ii) $Na_2\underline{B}_4O_7.10H_2O$

Ans :

(i) Molar mass of $(NH_4)_2PtCl_6$

$$= (14 + 4) \times 2 + 195 + 6 \times 35.5$$

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$= 36 + 195 + 213 = 444$ g

$\%$ of Pt $= \frac{195}{444} \times 100 = 43.9\%$

(ii) Molar mass of $Na_2B_4O_7.10H_2O$

$= 2 \times 23 + 4 \times 11 + 7 \times 16 + 10 \times 18$

$= 46 + 44 + 112 + 180 = 382$ g

$\%$ of B $= \frac{44}{382} \times 100 = 11.5\%$

188. Calculate the percentage of the following :

(a) Carbon in Ethyne (C_2H_2).
(b) Calcium in Calcium carbonate ($CaCO_3$).
(c) Nitrogen in Ammonia (NH_3).
(d) Oxygen in water (H_2O).
(e) Nitrogen in Urea $(NH_2)_2CO$.

Ans :

(a) Molecular weight of Ethyne (C_2H_2)

$= 2 \times 12 + 1 \times 2 = 24 + 2 = 26$ g

$\%$ of Carbon $= \frac{24}{26} \times 100 = 92.30\%$

(b) Molecular weight of Calcium carbonate ($CaCO_3$)

$= 40 + 12 + 48 = 100$ g

$\%$ of Calcium $= \frac{40}{100} \times 100 = 40\%$

(c) Molecular weight of Ammonia (NH_3)

$= 14 + 3 = 17$ g

$\%$ of Nitrogen $= \frac{14}{17} \times 100 = 82.35\%$

(d) Molecular weight of Water (H_2O)

$= 2 + 16 = 18$ g

$\%$ of Oxygen $= \frac{16}{18} \times 100 = 88.88\%$

(e) Molecular weight of Urea $[(NH_2)_2CO]$

$= 28 + 4 + 12 + 16 = 60$ g

$\%$ of Nitrogen $= \frac{28}{60} \times 100 = 46.66\%$

189. Determine the molecular mass of the following:

(i)	$Mg(NO_3)_2$	(ii)	Na_2SO_4
(iii)	HCl	(iv)	NH_3
(v)	$ZnSO_4$	(vi)	$C_6H_{12}O_6$
(vii)	$Fe_2(SO_4)_3$	(vi)	$MgCl_2$
(ix)	$PbSO_4$	(x)	$NaClO$
(xi)	$Zn(NO_3)_2$	(xii)	KNO_2
(xiii)	Ca_3N_2	(xiv)	$Ca(HSO_3)_2$
(xv)	Cu_2S		

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Ans :

(i) The molecular mass of $Mg(NO_3)_2$

$=$ Mass of Mg $+ N_2 + O_6$

$= 24 + (2 \times 14) + (6 \times 16)$

$= 24 + 28 + 96 = 148$ amu

(ii) The molecular mass of Na_2SO_4

$= (2 \times 23) + 32 + (4 \times 16)$

$= 46 + 32 + 64 = 142$ amu

(iii) The molecular mass of HCl

$= 1 + 35.5 = 36.5$ amu

(iv) The molecular mass of NH_3

$= 14 + (3 \times 1)$

$= 14 + 3 = 17$ amu

(v) The molecular mass of $ZnSO_4$

$= 65 + 32 + (4 \times 16)$

$= 65 + 32 + 64 = 161$ amu

(vi) The molecular mass of $C_6H_{12}O_6$

$= (6 \times 12) + (12 \times 1) + (6 \times 16)$

$= 72 + 12 + 96 = 180$ amu

(vii) The molecular mass of $Fe_2(SO_4)_3$

$= (56 \times 2) + (32 \times 3) + (12 \times 16)$

$= 112 + 96 + 192 = 400$ amu

(viii) The molecular mass of $MgCl_2$

$= 24 + (35.5 \times 2) = 24 + 71 = 95$ amu

(ix) The molecular mass of $PbSO_4$

$= 207 + 32 + 16 \times 4$

$= 207 + 32 + 64 = 303$ amu

(x) The molecular mass of $NaClO$

$= 23 + 35.5 + 16 = 74.5$ amu

(xi) The molecular mass of $Zn(NO_3)_2$

$= 65 + 2 \times [14 + (3 \times 16)]$

$= 65 + 2 \times (14 + 48)$

$= 65 + (2 \times 62)$

$= 65 + 124 = 189$ amu

(xii) The molecular mass of KNO_2

$= 39 + 14 + 16 \times 2$

$= 39 + 14 + 32 = 85$ amu

(xiii) The molecular mass of Ca_3N_2

$= 40 \times 3 + 14 \times 2$

$= 120 + 28 = 148$ amu

(xiv) The molecular mass of $Ca(HSO_3)_2$

$=$ Mass of Ca $+ H_2 + S_2 + O_6$

$= 40 + 2 + 2 \times 32 + 6 \times 16$

$= 40 + 2 + 64 + 96 = 202$ amu

(xv) The molecular mass of Cu_2S

$= 63.5 \times 2 + 32$

$= 127 + 32 = 159$ amu

190. Calculate the percentage composition by weight of the following compounds:

(i) Water (H_2O)
(ii) Ammonia (NH_3)
(iii) Methane (CH_4)
(iv) Hydrochloric acid (HCl)
(v) Ethane (C_2H_6)
(vi) Calcium nitrate [$Ca(NO_3)_2$]
(vii) Nitric oxide (NO)
(viii) Magnesium chloride ($MgCl_2$)
(ix) Calcium carbonate ($CaCO_3$)
(x) Sodium peroxide (Na_2O_2)

Ans :

(i) Water: Chemical formula = H_2O

Relative molar mass = $2 + 16 = 18$ amu

$$\% \text{ of Hydrogen} = \frac{2}{18} \times 100 = 11.11\%$$

$$\% \text{ of Oxygen} = \frac{16}{18} \times 100 = 88.89\%$$

(ii) Ammonia: Chemical formula = NH_3

Relative molar mass = $14 + 3 = 17$ amu

$$\% \text{ of Nitrogen} = \frac{14}{17} \times 100 = 82.35\%$$

$$\% \text{ of Hydrogen} = \frac{3}{17} \times 100 = 17.64\%$$

(iii) Methane: Chemical formula = CH_4

Relative molar mass = $12 + 4 = 16$ amu

$$\% \text{ of Carbon} = \frac{12}{16} \times 100 = 75\%$$

$$\% \text{ of Hydrogen} = \frac{4}{16} \times 100 = 25\%$$

(iv) Hydrochloric acid: Chemical formula = HCl

Relative molar mass = $1 + 35.5 = 36.5$ amu

$$\% \text{ of Hydrogen} = \frac{1}{36.5} \times 100 = 2.73\%$$

$$\% \text{ of Chlorine} = \frac{35.5}{36.5} \times 100 = 97.26\%$$

(v) Ethane: Chemical formula = C_2H_6

Relative molar mass = $24 + 6 = 30$ amu

$$\% \text{ of Carbon} = \frac{24}{30} \times 100 = 80\%$$

$$\% \text{ of Hydrogen} = \frac{6}{30} \times 100 = 20\%$$

(vi) Calcium nitrate :

Chemical formula = $Ca(NO_3)_2$

Relative molar mass = $40 + 28 + 96 = 164$ amu

$$\% \text{ of Calcium} = \frac{40}{164} \times 100 = 24.39\%$$

$$\% \text{ of Nitrogen} = \frac{28}{164} \times 100 = 17.07\%$$

$$\% \text{ of Oxygen} = \frac{96}{164} \times 100 = 58.53\%$$

(vii) Nitric oxide: Chemical formula = NO

Relative molar mass = $14 + 16 = 30$ amu

$$\% \text{ of Nitrogen} = \frac{14}{30} \times 100 = 46.66\%$$

$$\% \text{ of Oxygen} = \frac{16}{30} \times 100 = 53.33\%$$

(viii) Magnesium chloride:

Chemical formula = $MgCl_2$

Relative molar mass = $24 + 71 = 95$ amu

$$\% \text{ of Magnesium} = \frac{24}{95} \times 100 = 25.26\%$$

$$\% \text{ of Chlorine} = \frac{71}{95} \times 100 = 74.74\%$$

(ix) Calcium carbonate:

Chemical formula = $CaCO_3$

Relative molar mass = $40 + 12 + 48 = 100$

$$\% \text{ of Calcium} = \frac{40}{100} \times 100 = 40\%$$

$$\% \text{ of Carbon} = \frac{12}{100} \times 100 = 12\%$$

$$\% \text{ of Oxygen} = \frac{48}{100} \times 100 = 48\%$$

(ix) Sodium peroxide:

Chemical formula = Na_2O_2

Relative molar mass = $46 + 32 = 78$

$$\% \text{ of Sodium} = \frac{46}{78} \times 100 = 58.97\%$$

$$\% \text{ of Oxygen} = \frac{32}{18} \times 100 = 41.03\%$$

CASE BASED QUEATIONS

191. Meera is studying chemical equations in her classroom. She learns that a skeleton equation represents a chemical change but is unbalanced, meaning the total number of atoms of each element on both sides is not equal. She decides to balance a skeletal equation where nitrogen gas reacts with hydrogen gas to yield ammonia gas: $N_2(g) + H_2(g) \rightarrow NH_3(g)$. She wants to apply the hit-and-trial method to find the correct

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coefficients.

(a) State the law of conservation of mass which makes it necessary to balance a chemical equation.

(b) Write the balanced chemical equation for the reaction studied by Meera, including state symbols.

(c) Name the alternative method to hit-and-trial used for balancing complex chemical equations.

Ans :

(a) The law of conservation of mass states that matter can neither be created nor be destroyed during a chemical reaction.

(b) 1. The balanced chemical equation is $N_2(g) + 3H_2(g) \rightarrow 2NH_2(g)$.
2. The equation is fully balanced as the total number of nitrogen and hydrogen atoms are equal on both the reactant and product sides.

(c) The partial equation method is the alternative straightforward way to balance complex chemical equations by assuming the reaction occurs in steps.

192. Rahul is examining a bag of agricultural fertilizer in his grandfather's farm. The label indicates that it contains superphosphate, which has the chemical formula $Ca(H_2PO_4)_2$. Rahul wants to calculate the exact percentage of phosphorus in this fertilizer to understand its nutrient value. He notes down the required atomic masses from his textbook: Ca = 40, H = 1, P = 31, and O = 16.

(a) Calculate the gram molecular mass of the fertilizer superphosphate $Ca(H_2PO_4)_2$.

(b) Calculate the percentage of phosphorus in the given fertilizer correct to one decimal place.

Ans :

(a) 1. Gram molecular mass
= At. mass Ca + 2 × [(2 × At. mass H) + At. mass P + (4 × At. mass O)].
2. Substitution: 40 + 2 × [2 + 31 + 64] → 40 + 2 × 97 → 234 g.

(b) 1. Percentage of P
= (Mass of P in 1 mole/Gram molecular mass) × 100. Mass of P
= 2 × 31 = 62 g.
2. Substitution: (62 / 234) × 100 → 26.5%.

193. Priya is preparing for a chemistry quiz on chemical nomenclature. She reads that the suffix '-ide' is added to the non-metal when naming binary compounds containing a metal and a non-metal. For compounds containing polyatomic radicals with oxygen, specific prefixes like 'hypo-' and 'per-', and suffixes like '-ite' and '-ate' are used depending on the varying number of oxygen atoms present in the formula.

(a) Name the compounds KClO and $KClO_2$ using the correct prefixes and suffixes based on the number of oxygen atoms.

(b) Name the compounds $KClO_3$ and $KClO_4$ using the correct prefixes and suffixes based on the number of oxygen atoms.

Ans :

(a) 1. $KClO_1$ is named Potassium hypochlorite because the prefix 'hypo' is used when oxygen atoms are less than two.
2. $KClO_2$ is named Potassium chlorite because the suffix 'ite' is used when there are exactly two oxygen atoms.

(b) 1. $KClO_3$ is named Potassium chlorate because the suffix 'ate' is used when there are exactly three oxygen atoms.
2. $KClO_4$ is named Potassium perchlorate because the prefix 'per' is used when oxygen atoms are more than three.

194. Sanjay is observing different gas jars and solid samples in the chemistry laboratory. He notices a jar of argon gas, a piece of solid sodium metal, a flask of ozone gas, and a sample of solid phosphorus. His teacher explains that different elements have different atomicity, which is the total number of atoms present in a single molecule, and that their chemical symbols are derived from English, Latin, or German names.

(a) State the atomicity of argon gas.

(b) State the atomicity of solid phosphorus.

(c) State the atomicity of ozone gas.

(d) Identify the element whose symbol is 'W' and state the language from which this symbol is derived.

Ans :

(a) The atomicity of argon gas is one because all noble gases possess monoatomic molecules.

(b) The atomicity of solid phosphorus is four, making it a tetra-atomic molecule.

(c) The atomicity of ozone gas is three, making it a tri-atomic molecule.

(d) The symbol 'W' stands for Tungsten, and it is derived from its German name, Wolfram.

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195. Anjali writes the balanced chemical equation for the decomposition of calcium carbonate as $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. Her teacher points out that while this balanced equation provides quantitative information and proves the law of conservation of mass, it still has certain limitations. It does not inform the observer about several physical and experimental parameters involved in the actual reaction.

(a) State one specific limitation of a chemical equation regarding the physical state of substances.

(b) State one specific limitation of a chemical equation regarding energy changes.

(c) State one specific limitation of a chemical equation regarding reaction completion.

(d) State one specific limitation of a chemical equation regarding the conditions of the reaction.

Ans :

(a) A chemical equation does not tell us about the physical state, such as whether a reacting substance is solid, liquid, or gas.

(b) A chemical equation does not inform whether heat is liberated or absorbed during the chemical reaction.

(c) A chemical equation does not indicate the rate at which the reaction proceeds or whether the reaction is reversible or irreversible.

(d) A chemical equation does not provide the concentration of the reactants and products or the specific conditions of temperature and pressure.

196. Rohan is working in the organic chemistry laboratory. He analyzes a volatile organic compound with a vapour density of 45. Through quantitative analysis, he determines its percentage composition to be Carbon = 26.66%, Hydrogen = 2.22%, and Oxygen = 71.19%. He uses the relative atomic masses (Carbon = 12, Hydrogen = 1, and Oxygen = 16) to find the exact chemical formula of the newly synthesized substance.

(a) Calculate the empirical formula of the given organic compound.

(b) Calculate the empirical formula mass of the compound.

(c) Determine the molecular formula of the compound.

Ans :

(a) 1. The relative number of atoms are:

$$C = \frac{26.6}{12} + = 2.22$$

$$H = \frac{2.22}{1} = 2.22$$

$$O = \frac{71.19}{16} = 4.45.$$

2. Dividing by the smallest value (2.22) gives the simplest ratio:

C = 1

H = 1

O = 2. The empirical formula is CHO_2.

(b) Empirical mass

= Atomic mass of C + Atomic mass of H + (2 × Atomic mass of O) → 12 + 1 + (2 × 16) → 45 u.

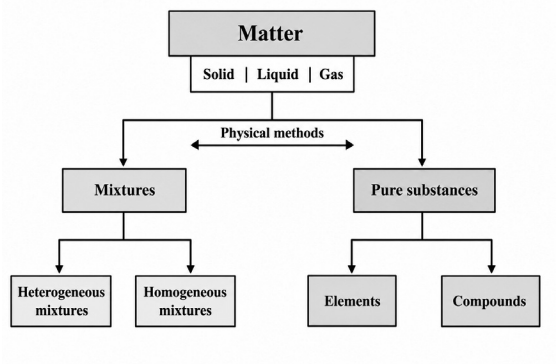
(c) Molecular mass

= 2 × Vapour Density → 2 × 45 = 90.

n = Molecular mass/Empirical mass → 90/45 = 2.

Molecular formula = 2 × (CHO_2) = $C_2H_2O_4$.

197. Vikram is studying the classification of matter in his textbook. He learns that matter can be broadly divided based on physical methods and chemical composition. The diagram below illustrates the hierarchical classification of matter into different categories based on uniformity and decomposition capabilities.



(a) Define the term 'element' as represented in the right branch of the diagram.

(b) State the difference between the two types of mixtures shown on the left side of the diagram.

(c) Define the term 'molecule' and state why it is considered the basic unit of matter.

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Ans :

(a) An element is a simple and pure form of matter in which a molecule is made up of atoms of the same kind and cannot be decomposed further.

(b) If the composition is not uniform throughout, it results in a heterogeneous mixture, whereas a mixture with a uniform composition is a homogeneous mixture.

(c) 1. A molecule is defined as the smallest particle of matter that can exist independently.
2. It is considered the basic unit of matter because it may contain similar or dissimilar atoms and can independently undergo physical changes.

198. Neha is researching the historical development of chemical nomenclature. She finds that early scientists used pictographic representations before the modern alphabetical IUPAC system was introduced. The diagram below displays the specific historical symbols proposed by a prominent early scientist for various common elements.

Hydrogen	⊙
Carbon	●
Oxygen	○
Phosphorus	☮
Sulphur	⊕
Iron	(I)
Copper	(C)
Lead	(L)

(a) Name the scientist who proposed the pictographic symbols shown in the diagram.

(b) Describe the new concept suggested by Berzelius to replace the pictographic system shown above.

(c) Give one reason why the initial letter suggested by Berzelius did not always agree with the English name of the element.

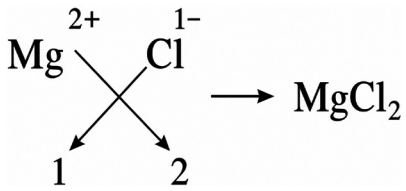
Ans :

(a) John Dalton was the scientist who used these types of pictographic symbols to represent elements.

(b) 1. Berzelius suggested representing elements by the initial letter of an element written in capitals, such as H for hydrogen.
2. If the first letter was the same for multiple elements, a two-letter system was used with a prominent second letter in lower case.

(c) The suggested symbol did not always agree with the English name because some symbols were taken from Latin names or other language names.

199. Arjun is practicing writing chemical formulae in his notebook. He uses a systematic method where valency numbers are crossed over to determine the correct subscripts for each atom. The diagram below demonstrates this specific method being applied to formulate a compound made of magnesium and chloride ions.



(a) State the name of the chemical compound whose formula is derived in the diagram, and identify its basic and acidic radicals.

(b) Using the method shown in the diagram, write the symbols, valencies, and final chemical formula for Potassium dichromate.

Ans :

(a) 1. The name of the chemical compound derived in the diagram is Magnesium chloride.
2. In this compound, magnesium (Mg^{2+}) is the basic radical, and chloride (Cl^{1-}) is the acidic radical.

(b) 1. The symbols with their respective valencies for Potassium dichromate are K^{1+} and $Cr_2O_7^{2-}$.
2. By interchanging the valency numbers to the lower right, the final formula is $K_2Cr_2O_7$.

200. Divya is reviewing how to make chemical equations more informative. Her teacher explains that standard skeletal equations lack details about states, heat changes, and conditions. The diagram below illustrates a fully annotated chemical equation that conveys additional physical and thermodynamic data about the reaction between carbon and oxygen.

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$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)} + 393.5\ kJ$$

[Exothermic reaction]

(a) Explain the significance of the symbols "(s)" and "(g)" as used in the given chemical sequence.

(b) Define an exothermic reaction as indicated in the diagram and state how an endothermic reaction is represented differently.

Ans :

(a) 1. The symbol "(s)" written after carbon indicates that the physical state of the reactant is solid.
2. The symbol "(g)" indicates that the physical state of the reactant oxygen and the product carbon dioxide is gas.

(b) 1. Exothermic reactions are those reactions in which heat is released, shown with a plus (+) sign on the products side.
2. Endothermic reactions are those in which heat is absorbed, represented by a plus (+) sign on the reactants side.

201. Karthik is studying the subatomic structure of atoms and how they achieve stability. He learns that atoms must have eight electrons in their outermost shell to attain a stable octet configuration. The diagram below shows the mathematical representation of electron transfer for two different elements to achieve this stable configuration.

$$\underset{2,8,1}{Na} - e^- \longrightarrow \underset{2,8}{Na^+} \quad \text{(monovalent)}$$

$$\underset{2,6}{O} + 2e^- \longrightarrow \underset{2,8}{O^{2-}} \quad \text{(divalent)}$$

(a) Name the specific type of positively charged ion formed in the first row of the diagram.

(b) Name the specific type of negatively charged ion formed in the second row of the diagram.

(c) State the nature of the elements that typically have one, two, or three electrons in their outermost shell.

(d) State the nature of the elements that typically have five, six, or seven electrons in their outermost shell.

Ans :

(a) The positively charged ion formed by the loss of an electron to attain stability is known as a cation.

(b) The negatively charged ion formed by the gain of electrons to complete the octet is known as an anion.

(c) Elements with one, two, or three electrons in their outermost shell are usually metals and are electro-positive in nature.

(d) Elements with five, six, or seven electrons in their outermost shell are normally non-metals and are electronegative in nature.

202. Sunita is performing a neutralization experiment in the school laboratory. She mixes a strong base with a strong acid to produce salt and water. Her teacher uses this reaction to explain how the resulting salt molecule consists of two distinct components. The diagram below illustrates the word equation for this specific chemical interaction.

Sodium hydroxide (Base) + Hydrochloric acid (Acid) ⟶ Sodium chloride (Salt) + Water

(a) Define the term 'radical' as used in chemistry.

(b) Identify the basic radical in the salt produced in the diagram.

(c) Identify the acidic radical in the salt produced in the diagram.

(d) Differentiate between a simple radical and a compound radical.

Ans :

(a) A radical is an atom or a group of atoms of the same or different elements that takes part in chemical reactions as a single unit and carries a positive or negative charge.

(b) The basic radical is the sodium radical (Na^+), as it is contributed by the base sodium hydroxide.

(c) The acidic radical is the chloride radical (Cl^-), as it is contributed by the hydrochloric acid.

(d) A simple radical is made up of an atom only, whereas a compound radical is made up of a group of two or more different atoms.

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CHAPTER 2

Chemical Changes and Reactions

SUMMARY

1. CHEMICAL CHANGE

A change during which the molecular composition gets totally altered, i.e. a change in which always a new product is formed with new property is called a chemical change.

1.1 Endothermic and exothermic change

If the energy is released during a reaction then the reaction is exothermic and if the energy is absorbed, then the reaction is endothermic.

For example, when paper is burnt, it forms carbon dioxide and water vapours along with energy in the form of heat and light.

Examples of chemical changes are:

(i) Burning of wood or paper
(ii) Rancidification of butter
(iii) Digestion of food

Examples Involving both Physical and Chemical Changes:

There are certain substances which undergo physical and chemical changes simultaneously. For example,

Heating of lead nitrate:

$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$$

(Chemical change)

$$\underset{\text{light yellow}}{PbO} \xrightarrow{\Delta} \underset{\text{reddish}}{PbO}$$

(Physical change)

1.2 Energy Change in Chemical Reaction:

Energy change always takes place during the chemical reaction. The energy is either released or absorbed during the chemical reaction.

2. CHEMICAL REACTION

The reaction in which elements or compounds undergo a chemical change with either the liberation or absorption of energy leading to the formation of one more product is called a chemical reaction.

2.1 Necessary Condition For Chemical Reaction:

For a chemical reaction, the particles must undergo effective collision, i.e. with proper energy and proper orientation. These conditions include heat, light, pressure, catalytic agent, etc.

2.2 Type of Chemical Reaction

The chemical reactions are classified as the following main types :

(i) Synthesis
(ii) Direct combination reaction
(iii) Decomposition reaction
(iv) Simple displacement
(v) Double decomposition reaction.

2.3 Synthesis Reaction

When two or more elements combine to give a single product then the reaction is called synthesis reaction. For example:

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

The different synthesis reactions are summarised as follows:

(i) Reaction of metals with oxygen:

Metal + Oxygen $\longrightarrow$ Metallic oxide

Silver and gold do not react with oxygen while metals from potassium to copper react with oxygen to form their respective metallic oxides. However, the reactivity decreases from potassium to copper. Metallic oxides formed are usually basic oxides and few are amphoteric oxides, e.g.

$$4\,K + O_2 \longrightarrow 2K_2O$$

(ii) Reaction of non-metals with oxygen: Non-metallic oxides are usually acidic oxides and very few are neutral oxides.

Non-metal + Oxygen $\longrightarrow$ Non-metallic oxide

$$C + O_2 \longrightarrow CO_2$$

$$S + O_2 \longrightarrow SO_2$$

(Sulphur burns with pale blue flame)

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(iii) Reaction of metals with chlorine:

$$2Na + Cl_2 \longrightarrow 2NaCl$$

(iv) Reaction of non-metals with chlorine:

$$2P + 5Cl_2 \longrightarrow 2PCl_5$$

(v) Reaction of metals with sulphur:

$$Zn + S \xrightarrow{\Delta} ZnS$$

(vi) Reaction of non-metals with sulphur:

$$\underset{\text{boiling}}{2S} + Cl_2 \longrightarrow \underset{\text{Sulphur monochloride}}{S_2Cl_2}$$

(vii) Reaction of metals with nitrogen: Metals like magnesium, calcium and aluminium directly combine with nitrogen on heating to form respective metallic nitrides.

$$\underset{\text{burning}}{3Mg} + N_2 \longrightarrow Mg_3N_2$$

(viii) Reaction of non-metals with nitrogen:

$$N_2 + 3H_2 \underset{450^\circ - 500^\circ C}{\overset{Fe - Mo}{\rightleftharpoons}} 2NH_3$$

(Haber's process)

$$N_2 + O_2 \underset{\text{Lightening}}{\overset{\text{Thunder and}}{=\!=\!=}} 2NO$$

2.4 Direct Combination Reaction

When two or more elements or compounds combine chemically to give a single product then the reaction is called direct combination reaction. (In this, two elements never combine).

$$2CO + O_2 \longrightarrow 2CO_2$$

The direct combination reactions can be summarized as:

(i) Reaction of lower oxides with oxygen to form higher oxides:
Carbon monoxide burns with pale blue flame:

$$2CO + O_2 \longrightarrow 2CO_2$$

Catalytic oxidation of sulphur dioxide:

$$2SO_2 + O_2 \underset{450^\circ C}{\overset{V_2O_5}{\longrightarrow}} 2SO_3$$

(ii) Reaction of soluble basic oxide with water: Soluble basic oxides react with water to form alkalies which turns red litmus to blue, e.g.

$$K_2O + H_2O \longrightarrow 2KOH$$

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

(iii) Reaction of acidic oxide with water: Acidic oxides react with water to form acids which turns blue litmus to red. Acidic oxides are also called acid anhydrides.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

$$P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$$

2.5 Decomposition Reaction:

The chemical reaction in which a compound breaks down to give two or more products (may be elements or compounds) on absorbing energy is called decombination or decomposition reaction.

The examples of decomposition reactions are:

(i) Effect of Heat on Metallic and Non-Metallic Nitrates:

(a) Non-metallic nitrate: Ammonium nitrate

$$NH_4NO_3 \xrightarrow{\Delta} \underset{\substack{\text{Nitrous oxide}\\ \text{or}\\ \text{Laughing gas}}}{N_2O} + 2H_2O$$

(b) In metallic nitrates, sodium and potassium nitrates on heating give oxygen as the only gaseous product.

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$$

$$2KNO_3 \xrightarrow{\Delta} 2KNO_2 + O_2$$

(c) From calcium nitrate to copper nitrate, all metallic nitrates on heating decompose to give their respective metallic oxides, oxygen and nitrogen dioxide.

$$2Ca(NO_3)_2 \xrightarrow{\Delta} 2CaO + 4NO_2 + O_2$$

$$2Zn(NO_3)_2 \xrightarrow{\Delta} 2ZnO + 4NO_2 + O_2$$

$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$$

$$2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + 4NO_2 + O_2$$

(d) Silver nitrate and mercury nitrate on heating give their respective metals, nitrogen dioxide and oxygen.

$$Hg(NO_3)_2 \xrightarrow{\Delta} Hg + 2NO_2 + O_2$$

$$2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$$

(ii) Effect of Heat on Metallic Carbonates:

(a) Sodium carbonate and potassium carbonate do not decompose on heating, i.e. they are stable towards heat.

(b) From calcium to copper all metallic carbonates decompose to give their respective metallic oxides and carbon dioxide.

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

$$ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$$

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$$PbCO_3 \xrightarrow{\Delta} PbO + CO_2$$

$$CuCO_3 \xrightarrow{\Delta} CuO + CO_2$$

(c) Silver carbonate and mercury carbonate on heating give respective metals, carbon dioxide and oxygen.

$$2HgCO_3 \xrightarrow{\Delta} 2Hg + 2CO_2 + O_2$$

$$2Ag_2CO_3 \xrightarrow{\Delta} 4Ag + 2CO_2 + O_2$$

(iii) Effect of Heat on Metallic Hydroxides

(a) Sodium hydroxide and potassium hydroxide do not decompose on heating, i.e. they are stable towards heat.

(b) From calcium to copper all metallic hydroxide decompose to give their respective metallic oxides and water.

$$Ca(OH)_2 \xrightarrow{\Delta} CaO + H_2O$$

$$Mg(OH)_2 \xrightarrow{\Delta} MgO + H_2O$$

$$Zn(OH)_2 \xrightarrow{\Delta} ZnO + H_2O$$

$$Pb(OH)_2 \xrightarrow{\Delta} PbO + H_2O$$

$$Cu(OH)_2 \xrightarrow{\Delta} CuO + H_2O$$

(c) Silver hydroxide and mercury hydroxide on heating decompose to give their respective metals, oxygen and water.

$$2Hg(OH)_2 \xrightarrow{\Delta} 2Hg + 2H_2O + O_2$$

$$4AgOH \xrightarrow{\Delta} 4Ag + 2H_2O + O_2$$

3. THERMAL DISSOCIATION REACTION

A reversible thermal decomposition reaction is called thermal dissociation reaction, e.g.

$$NH_4Cl \underset{\text{Cool}}{\overset{\Delta}{\rightleftharpoons}} NH_3 + HCl$$

3.1 Activity series

The series in which the metals are arranged in the decreasing order of their reactivity is called activity series.

K	Potassium	Reactivity Increases ↑	↓ Reactivity Decrease
Ca	Calcium		
Na	Sodium		
Mg	Magnesium		
Al	Aluminium		
Zn	Zinc		
Fe	Iron		
Pb	Lead		
[H]	Hydrogen		
Cu	Copper		
Hg	Mercury		
Ag	Silver		
Au	Gold		
Pt	Platinum		

4. SIMPLE DISPLACEMENT REACTION

The elements lying above in the metal activity series displace the elements lying below in the metal activity series from their salt solutions. Such reactions are called simple displacement reactions.

Metals lying above hydrogen in the metal activity series displace hydrogen from water and dilute acids. However, metals lying below hydrogen like copper, silver, gold, etc. do not displace hydrogen on reaction with dilute acids and water.

(i) Sodium, potassium and calcium displace hydrogen from cold water.

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2$$

$$2K + 2H_2O \longrightarrow 2KOH + H_2$$

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$$

(ii) Rest of the metals react with steam to form their respective oxides with the liberation of hydrogen.

$$Mg + H_2O \longrightarrow MgO + H_2$$

$$Zn + H_2O \longrightarrow ZnO + H_2$$

$$3Fe + 4H_2O \underset{\text{heated}}{\rightleftharpoons} Fe_3O_4 + 4H_2$$

(iii) Copper, silver, gold, etc. do not react with water under any condition.

Metals react with dilute acids as follows:

(i) Sodium, potassium and calcium react explosively with dilute acids to liberate hydrogen.

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$$2K + \underset{\text{dil.}}{2HCl} \longrightarrow 2KCl + H_2$$

$$2Na + \underset{\text{dil.}}{2HCl} \longrightarrow 2NaCl + H_2$$

$$Ca + \underset{\text{dil.}}{2HCl} \longrightarrow CaCl_2 + H_2$$

(ii) Magnesium, aluminium and zinc react with dilute acids less vigorously to liberate hydrogen.

$$Mg + \underset{\text{dil.}}{2HCl} \longrightarrow MgCl_2 + H_2$$

$$Zn + \underset{\text{dil.}}{2HCl} \longrightarrow ZnCl_2 + H_2$$

$$2Al + \underset{\text{dil.}}{6HCl} \longrightarrow 2AlCl_3 + 3H_2$$

(iii) Iron reacts silently and slowly with dilute acids.

$$Fe + \underset{\text{dil.}}{2HCl} \longrightarrow FeCl_2 + H_2$$

$$Fe + \underset{\text{dil.}}{H_2SO_4} \longrightarrow FeSO_4 + H_2$$

(iv) Copper, silver and gold do not react with dilute acids to liberate hydrogen.

The more electronegative element displaces less electronegative element from its salt solution. For example, in case of halogens;

F – Fluorine

Cl – Chlorine

Br – Bromine and

I – Iodine

$$\underset{\text{colourless}}{2KI} + Cl_2 \longrightarrow 2KCl + \underset{\text{deep yellow}}{I_2}$$

$$2KBr + Cl_2 \longrightarrow 2KCl + \underset{\text{reddish brown}}{Br_2}$$

5. DOUBLE DECOMPOSITION REACTION

The reaction in which the interchange of radicals takes place in their solution form is called double decomposition (double displacement) reaction.

The double decomposition reactions are of two types :

(i) Neutralization (ii) Precipitation

Neutralization is a reaction in which acids react with bases to form salt and water as the only products. This reaction is employed for the preparation of soluble salts.

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

$$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$$

$$H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$$

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

During double decomposition precipitation reaction two soluble salts combine in their solution forms to give one insoluble compound in the form of precipitate and other soluble compound. This method is employed for the preparation of insoluble salts.

$$BC + DE \longrightarrow BE\downarrow + DC$$

For example,

$$AgNO_3 + NaCl \longrightarrow \underset{\text{white ppt.}}{AgCl\downarrow} + NaNO_3$$

$$BaCl_2 + Na_2SO_4 \longrightarrow \underset{\text{white ppt.}}{BaSO_4\downarrow} + 2NaCl$$

$$CuSO_4 + 2NaOH \longrightarrow \underset{\text{pale blue ppt.}}{Cu(OH)_2\downarrow} + Na_2SO_4$$

$$Pb(NO_3)_2 + Na_2SO_4 \longrightarrow \underset{\text{white ppt.}}{PbSO_4\downarrow} + 2NaNO_3$$

$$Pb(NO_3)_2 + 2KI \longrightarrow \underset{\text{yellow ppt.}}{PbI_2\downarrow} + 2KNO_3$$

6. REDUCTION REACTION:

The process of gain of electrons is called reduction.

For example, $Fe^{3+} + e^- \longrightarrow Fe^{2+}$

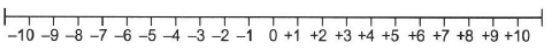
7. OXIDATION REACTION:

The process of loss of electrons is called oxidation.

For example, $Zn \longrightarrow Zn^{2+} + 2e^-$

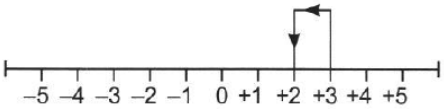
8. REDOX REACTION:

The reactions in which oxidation and reduction take place simultaneously is called redox reaction. The process of oxidation and reduction can be easily explained on the basis of the following number line:



In the process of reduction, the number decreases according to the number line.

For example, $Fe^{3+} \longrightarrow Fe^{2+}$ (Reduction, i.e. gain of e^-)



$Fe^{3+} + e^- \longrightarrow Fe^{2+}$

In the process of oxidation, the number increases according to the number line.

$Fe^{2+} \longrightarrow Fe^{3+}$ (Oxidation, i.e. loss of e^-)

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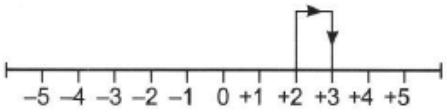

$Fe^{2+} - e^- \longrightarrow Fe^{3+}$

8.1 Oxidising and Reducing Agents:

Reducing agents are the electron donors. For example, Metals are reducing agents.
Oxidizing agents are electron acceptors. For example, Non-metals are oxidizing agents.
Reducing agent in the reaction gets oxidized and the oxidizing agent in the reaction gets reduced.

9. PHOTOCHEMICAL REACTION

The chemical reactions which proceed in the presence of light are called photochemical reactions.
e.g. Photosynthesis, Decomposition of silver nitrates.

10. ELECTROCHEMICAL REACTION:

The chemical reactions which proceed in the presence of electricity are called electrochemical reactions.
e.g. Electrolysis of Acidulated water, Electrolysis of molten NaCl.

11. BURNING (COMBUSTION)

Combustion is a chemical process in which substances combine with oxygen to form their respective oxides with the liberation of energy in the form of heat or light.

11.1 Necessary Conditions for Combustion :

The necessary conditions for burning are as follows :

(i) The presence of supporter of combustion. The common example is oxygen.
(ii) The presence of combustible substance. For example, wood, fuel, paper etc.
(iii) The attainment of ignition temperature. It is the minimum temperature that a substance must attain before it catches fire.

12. BALANCING OF OXYGEN AND CARBON DIOXIDE IN THE ATMOSPHERE

Life on earth exists due to the sensitive balance between oxygen and carbon dioxide. Both of these gases are essential for the sustenance of human life. However, both of these gases are used up during

(i) Respiration – Oxygen
(ii) Photosynthesis – Carbon dioxide.

The balance between the amount of these gases is maintained as discussed below.

OBJECTIVE QUESTIONS

1. Which of the following is strictly classified as a chemical property of matter?
(A) Melting point
(B) Solubility
(C) Combustibility
(D) Density

Ans : (C)

Chemical properties relate to the chemical reactivity of matter, including combustibility, toxicity, and reaction with acids and bases. Melting point, solubility, and density are associated with the physical state of matter and are therefore classified strictly as physical properties of the substance.

2. Which of the following statements accurately describes a characteristic of a physical change?
(A) It is usually permanent and irreversible.
(B) A net energy change always occurs.
(C) The total mass of the substance changes.
(D) No new chemical substance is formed.

Ans : (D)

During a physical change, the chemical composition of the original substance remains entirely unchanged, meaning no new chemical substances are formed. The change is temporary and reversible, with no alteration in total mass and no net energy change taking place

3. Which among the given processes represents a permanent chemical change?
(A) Sublimation of dry ice
(B) Dissolving sugar in water
(C) Glowing of an electric bulb
(D) Rotting of a banana

Ans : (D)

Rotting of a banana involves complex biochemical reactions that alter the chemical composition of the fruit, forming entirely new substances. This process is permanent and irreversible.

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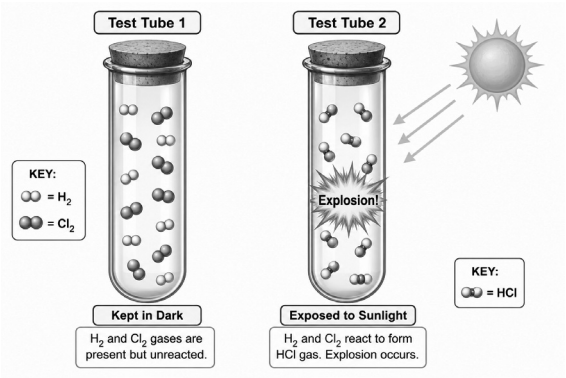
Sublimation, dissolving sugar, and glowing of a bulb remain purely physical changes without new products.

4. The diagram shows an experiment involving hydrogen and chlorine gases. What can be concluded about the role of sunlight in this reaction?



(A) Sunlight acts as a negative catalyst, inhibiting the reaction.
(B) Sunlight provides the activation energy for this photochemical reaction.
(C) Sunlight is a reactant that is consumed during the formation of HCl.
(D) Sunlight acts as a physical solvent for the gaseous reactants.

Ans : (B)

The reaction between hydrogen and chlorine is a photochemical reaction, meaning it is initiated by light. Sunlight provides the necessary activation energy in the form of photons to break the bonds in the reactant molecules (H_2 and Cl_2), allowing them to react and form hydrogen chloride. Without this energy input, the reaction does not occur at room temperature.

5. When solid lead nitrate and solid potassium iodide are mixed, a chemical reaction occurs primarily due to
(A) Application of extremely high pressure
(B) Absorption of intense light energy
(C) Close contact between the reactants
(D) Addition of a strong positive catalyst

Ans : (C)

Certain chemical reactions occur simply by mixing two substances in their solid states. When lead nitrate and potassium iodide are brought into close contact, their particles collide and react immediately to produce a yellow precipitate of lead iodide without needing additional energy.

6. Which specific gas is evolved when chlorine water is exposed to direct sunlight?
(A) Hydrogen
(B) Oxygen
(C) Nitrogen
(D) Carbon dioxide

Ans : (B)

When sunlight strikes chlorine water, a photochemical reaction takes place. The radiant light energy decomposes the hypochlorous acid formed in the aqueous solution, resulting in the evolution of oxygen gas bubbles, demonstrating light acting as a crucial condition for the chemical change.

7. In the industrial manufacture of ammonia from nitrogen and hydrogen, what specific role does molybdenum play?
(A) It acts as a powerful positive catalyst.
(B) It acts as a retarding negative catalyst.
(C) It acts as a chemical promoter.
(D) It provides the required heat energy.

Ans : (C)

Molybdenum acts as a promoter during the manufacture of ammonia. A promoter is a specific substance added directly to a solid catalyst to significantly improve its overall performance. In this process, molybdenum increases the catalytic efficiency of the primary iron catalyst.

8. Which of the following substances effectively acts as a negative catalyst to retard the decomposition of hydrogen peroxide?
(A) Manganese dioxide
(B) Phosphoric acid
(C) Finely divided iron
(D) Ethyl alcohol

Ans : (B)

A negative catalyst, often called an inhibitor, is employed to retard the rate of a specific chemical reaction. Phosphoric acid effectively decreases the rate at which hydrogen peroxide decomposes, thus acting as a negative catalyst to stabilize the compound during its long-term storage.

9. What distinct colour change is observed when concentrated sulphuric acid is added to a piece of copper?
(A) A blue solution turns bright green.
(B) A colourless solution turns yellow.
(C) An orange solution turns green.
(D) The brown metal forms a blue solution.

Ans : (D)

When concentrated sulphuric acid is added

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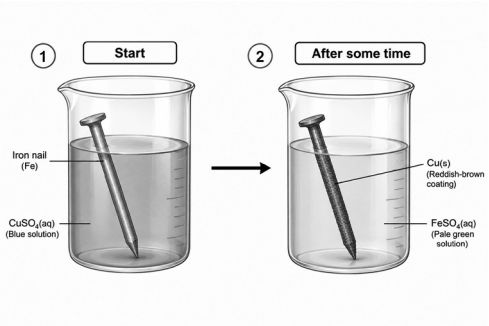
to a brown piece of copper metal, a vigorous chemical reaction takes place. This reaction produces a blue-coloured aqueous solution of copper sulphate, along with liquid water and the evolution of pungent sulphur dioxide gas.

10. The diagram illustrates an experiment where an iron nail is placed in a copper sulphate solution. This change is best classified as which type of reaction?



(A) A thermal decomposition reaction caused by the heat of the solution.
(B) A double decomposition reaction where iron and copper exchange places.
(C) A direct combination reaction between the iron nail and the solution.
(D) A single displacement reaction where iron displaces copper from its salt solution.

Ans : (D)

This is a classic example of a single displacement reaction. Iron is more reactive than copper, so it displaces copper from the copper sulphate solution according to the activity series. Iron atoms lose electrons to become Fe^{2+} ions (which form the green solution), while Cu^{2+} ions gain electrons to become solid copper metal (the reddish-brown deposit).

11. Why is silver nitrate solution strictly stored in dark brown bottles inside chemical laboratories?
(A) To prevent it from reacting with atmospheric oxygen
(B) To prevent it from decomposing under the action of light
(C) To enhance its concentration through accelerated evaporation
(D) To protect it from sudden ambient temperature changes

Ans : (B)

Silver nitrate is highly sensitive to light and readily undergoes photochemical decomposition when exposed. Storing the solution in dark brown bottles blocks out radiant light energy, preventing the chemical breakdown of the compound into metallic silver, nitrogen dioxide, and oxygen gas.

12. When an aqueous sodium hydroxide solution is mixed with a ferrous sulphate solution, what is the colour of the resulting precipitate?
(A) Curdy white
(B) Dirty green
(C) Brilliant yellow
(D) Reddish-brown

Ans : (B)

Mixing a ferrous sulphate solution with a sodium hydroxide solution results in a double decomposition reaction. This chemical change is visually characterized by the immediate formation of an insoluble solid substance, specifically identified as a dirty green precipitate of ferrous hydroxide.

13. A substance is heated, causing a transformation. The properties before and after the change are recorded. Based on the data, what type of change has occurred?

Property	**Before Heating**	**After Heating**
Chemical Composition	$Zn(OH)_2$	$ZnO + H_2O$
Formation of new substance	No	Yes
Reversibility by simple means	-	No

(A) A physical change, because a state change occurs.
(B) A chemical change, because a new substance is formed.
(C) A reversible change, because it was caused by heating.
(D) A sublimation process, because a solid was heated.

Ans : (B)

The table clearly shows that the chemical composition changes from zinc hydroxide to zinc oxide and water. The formation of new substances with different chemical formulas is the defining characteristic of a chemical change. While heat is supplied, the change is not easily reversible and is therefore a permanent chemical decomposition.

14. Which of the following accurately represents a direct combination reaction between two

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separate chemical compounds?

(A) Carbon and oxygen forming carbon dioxide
(B) Ammonia and hydrogen chloride forming ammonium chloride
(C) Iron and sulphur forming iron (II) sulphide
(D) Sulphur dioxide and oxygen forming sulphur trioxide

Ans : (B)

A combination reaction between two compounds occurs when they merge entirely to form a single product. Ammonia and hydrogen chloride are both distinct compounds that react directly to form a new solid compound, ammonium chloride. The other options involve elemental reactants.

15. The table summarises four general types of reactions using symbolic representation, where A, B, C, and D are different substances. Which reaction represents a direct combination (synthesis) reaction?

Reaction ID	Reactant(s)	Product(s)
1	AB	A + B
2	A + B	AB
3	AB + C	CB + A
4	AB + CD	AD + CB

(A) Reaction 1
(B) Reaction 2
(C) Reaction 3
(D) Reaction 4

Ans : (B)

A direct combination or synthesis reaction is defined as a reaction in which two or more simpler substances (elements or compounds) combine to form a single, more complex product. Reaction 2, where reactants A and B combine to form a single product AB, correctly represents this pattern. The other options represent decomposition, displacement, and double decomposition, respectively.

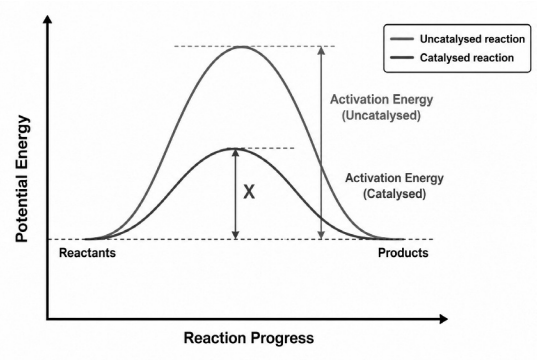
16. What specific chemical products are formed when lead nitrate is heated strongly in a dry test tube?

(A) Lead monoxide, nitrogen dioxide, and oxygen
(B) Lead monoxide and nitrogen dioxide only
(C) Pure lead metal, nitrogen, and oxygen
(D) Lead nitrite and oxygen gas

Ans : (A)

Thermal decomposition of lead nitrate occurs rapidly upon strong heating. The white crystals break down to leave a yellow solid residue of lead monoxide, while simultaneously releasing a reddish-brown gas called nitrogen dioxide along with colourless oxygen gas into the surrounding environment.

17. The diagram shows the energy pathways for a reaction. Point 'X' on the catalysed pathway represents the peak of the energy profile. What does this point signify?



(A) The net energy released by the overall reaction.
(B) The activation energy of the original, uncatalysed reaction.
(C) The energy of the activated complex via the catalysed pathway.
(D) The final energy state of the products after the reaction.

Ans : (C)

A catalyst provides an alternative reaction mechanism with a lower activation energy. The peak of an energy profile diagram represents the transition state, or activated complex, which is the highest energy point during the reaction. Point 'X' thus signifies the energy of the activated complex for the catalysed reaction, which is lower than that of the uncatalysed pathway.

18. Which of the following highly reactive metal hydroxides fundamentally resists decomposition upon intense heating?

(A) Calcium hydroxide
(B) Zinc hydroxide
(C) Sodium hydroxide
(D) Copper hydroxide

Ans : (C)

The thermal stability of metal compounds is directly related to the inherent reactivity of the parent metal. Highly reactive metals form exceptionally stable compounds. Sodium is a highly reactive metal, and its hydroxide remains

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stable to heat, refusing to undergo thermal decomposition.

19. Which gas is rapidly evolved with brisk effervescence when dilute hydrochloric acid is added to calcium carbonate?
(A) Oxygen
(B) Hydrogen
(C) Carbon dioxide
(D) Chlorine

Ans : (C)

The addition of dilute hydrochloric acid to solid calcium carbonate initiates a chemical reaction characterized by rapid gas evolution. The escaping gas is carbon dioxide, which forms visible bubbles in the liquid solution, a phenomenon commonly referred to by chemists as effervescence.

20. The synthesis of ammonia (Haber's process) is studied under different conditions. Based on the data, what is the most accurate description of Molybdenum's (Mo) role?

Trial	**Catalyst**	**Promoter**	**Rate of Ammonia Production (units/min)**
1	None	Mo	0
2	Fe	None	50
3	Fe	Mo	95

(A) Mo is a positive catalyst for the reaction.
(B) Mo is an inhibitor that slows down the reaction.
(C) Mo is a promoter that increases the efficiency of the iron catalyst.
(D) Mo is a reactant that is consumed during the reaction.

Ans : (C)

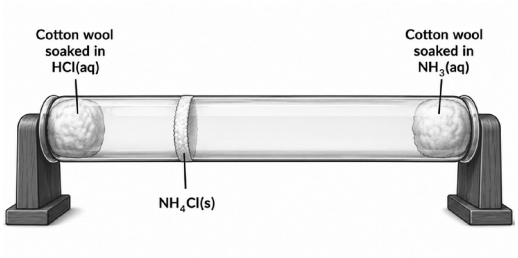
Trial 1 shows that Molybdenum by itself has no catalytic activity. Trial 2 shows that Iron acts as a catalyst. Trial 3 shows that when Mo is added with Fe, the rate of reaction increases significantly compared to using Fe alone. A substance that enhances a catalyst's activity is known as a promoter.

21. What specific chemical products are obtained at the respective electrodes during the electrolytic decomposition of acidulated water?
(A) Hydrogen at the anode and oxygen at the cathode
(B) Oxygen at the anode and hydrogen at the cathode
(C) Hydrogen and oxygen simultaneously at the anode
(D) Oxygen and liquid water at the cathode

Ans : (B)

When direct electric current continuously passes through acidulated water, it undergoes electrolytic decomposition. Combustible hydrogen gas is liberated at the negative electrode, known as the cathode, while oxygen gas is simultaneously evolved at the positive electrode, known as the anode.

22. The experiment shown demonstrates the reaction between ammonia and hydrogen chloride gases to form a solid. This reaction is best classified as:



(A) Direct combination or synthesis.
(B) Thermal dissociation.
(C) Single displacement.
(D) Photochemical decomposition.

Ans : (A)

Explanation: A direct combination, or synthesis, reaction occurs when two or more simple substances combine to form a single, more complex product. In this case, ammonia gas (NH_3) and hydrogen chloride gas (HCl) react directly to form a single product, solid ammonium chloride (NH_4Cl). This fits the general form A + B → AB.

23. How does a thermal dissociation reaction fundamentally differ from a standard thermal decomposition reaction?
(A) Thermal dissociation is an irreversible chemical process.
(B) Thermal dissociation is a reversible chemical process.
(C) Thermal dissociation inherently requires an electric current.
(D) Thermal dissociation only occurs within aqueous liquids.

Ans : (B)

Thermal dissociation is a completely reversible chemical change where a substance breaks down upon heating, and the resulting simpler products

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recombine to form the original substance upon cooling. In contrast, thermal decomposition remains entirely permanent and irreversible after external heat is removed.

24. A student performs several experiments and records the colour changes. Which experiment from the table demonstrates a chemical change?

Experiment	Reactants	Initial Colour of Solution	Final Colour of Solution
1	Iron nail in $CuSO_4$ solution	Blue	Light Green
2	Solid iodine crystals heated	-	Violet vapour formed
3	Water cooled to 0°C	Colourless	-
4	Sugar dissolved in water	Colourless	Colourless

(A) Experiment 1
(B) Experiment 2
(C) Experiment 3
(D) Experiment 4

Ans : (A)

In Experiment 1, the change in colour from blue (copper sulphate) to light green (iron sulphate) indicates the formation of a new substance, which is a characteristic of a chemical change. Experiment 2 (sublimation), 3 (freezing), and 4 (dissolution) are all physical changes where no new chemical substance is formed.

25. What distinctive visual observation occurs when a small piece of magnesium ribbon is dropped into dilute sulphuric acid?
(A) The clear solution instantly turns deep blue.
(B) A thick, curdy white precipitate is formed.
(C) Brisk effervescence with the evolution of hydrogen gas.
(D) Reddish-brown fumes of nitrogen dioxide are vigorously evolved.

Ans : (C)

Magnesium is situated prominently above hydrogen in the electrochemical activity series. When added to dilute sulphuric acid, the highly active magnesium metal rapidly displaces hydrogen from the acid, resulting in brisk effervescence and the evolution of combustible hydrogen gas within the solution.

26. What specific chemical event happens when an aqueous barium chloride solution is carefully mixed with a sodium sulphate solution?
(A) A brilliant yellow precipitate of sodium chloride rapidly forms.
(B) A dense white precipitate of barium sulphate quickly forms.
(C) A toxic gas with a rotten egg smell is continuously evolved.
(D) The mixed solution turns entirely colourless without forming any precipitate.

Ans : (B)

Mixing barium chloride and sodium sulphate solutions immediately triggers a double decomposition precipitation reaction. The acidic and basic radicals exchange places to form aqueous sodium chloride and an insoluble white precipitate of barium sulphate, making the chemical change easily visible and separable.

27. Which corresponding chemical equation correctly represents the precise neutralisation of an insoluble base with an acid?
(A) $NaOH + HCl \rightarrow NaCl + H_2O$
(B) $KOH + HNO_3 \rightarrow KNO_3 + H_2O$
(C) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
(D) $NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

Ans : (C)

Neutralisation involves an acid reacting with a base to form salt and water. Copper oxide is a known insoluble base that reacts with dilute sulphuric acid to produce soluble copper sulphate and water. The other provided options feature highly soluble bases, known as alkalis.

28. According to the established electrochemical activity series, which of the following metals can readily displace copper from a solution of copper sulphate?
(A) Silver
(B) Gold
(C) Zinc
(D) Platinum

Ans : (C)

According to the fundamental rules of the electrochemical activity series, a more reactive element displaces a less reactive one from its salt solution. Zinc is placed significantly higher

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than copper in the series, making it sufficiently reactive to displace copper effectively.

29. An experiment investigates the decomposition of potassium chlorate ($KClO_3$). The results are tabulated below. Which conclusion can be drawn about the role of Substance X?

Experiment	Reactants	Temperature	Time to collect 10 mL O_2
1	$KClO_3$	700°C	30 minutes
2	$KClO_3$ + Substance X	300°C	5 minutes

(A) Substance X acts as a negative catalyst by lowering the temperature.
(B) Substance X acts as a promoter by increasing the reaction time.
(C) Substance X acts as a positive catalyst by increasing the reaction rate at a lower temperature.
(D) Substance X is a reactant that combines with $KClO_3$.

Ans : (C)

The data shows that with Substance X, the reaction occurs much faster (5 mins vs 30 mins) and at a significantly lower temperature (300°C vs 700°C). A substance that increases the rate of a chemical reaction without being consumed is a positive catalyst. Substance X (manganese dioxide) demonstrates these properties.

30. In the chemical reaction represented by $H_2S + Cl_2 \rightarrow 2HCl + S$, which specific substance firmly acts as the oxidizing agent?
(A) Hydrogen sulphide
(B) Chlorine
(C) Hydrogen chloride
(D) Elemental sulphur

Ans : (B)

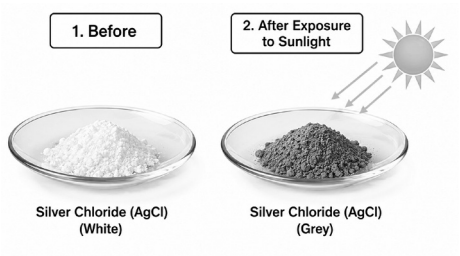
In this specific chemical reaction, chlorine actively removes hydrogen directly from hydrogen sulphide to form hydrogen chloride. Since chlorine causes the total removal of hydrogen from another compound, it functions inherently as the oxidizing agent according to the classical concept of redox reactions.

31. According to the modern electronic concept of oxidation-reduction, what specifically defines the fundamental process of reduction?
(A) Loss of positive protons by a species
(B) Gain of negatively charged electrons by a species
(C) Loss of negatively charged electrons by a species
(D) Gain of neutral neutrons by a species

Ans : (B)

Under the strict electronic concept of chemical redox reactions, reduction is fundamentally defined as the complete gain of one or more electrons by an atom, molecule, or ion. Conversely, oxidation is defined as the corresponding process involving the loss of electrons.

32. The change observed in the watch glass is an example of photochemical decomposition. What are the chemical products of this reaction?



(A) Silver oxide and chlorine gas.
(B) Silver metal and oxygen gas.
(C) Silver nitrate and chlorine gas.
(D) Silver metal and chlorine gas.

Ans : (D)

Photochemical decomposition is the breakdown of a substance by light energy. In this reaction, white silver chloride (AgCl) absorbs energy from sunlight and decomposes into its constituent elements: solid silver and chlorine gas. The fine particles of silver metal that are formed appear grey, causing the visible colour change.

33. Which of the following everyday chemical processes is inherently classified as an exothermic reaction?
(A) Thermal decomposition of solid calcium carbonate
(B) Rapid burning of natural gas in air
(C) Heating solid carbon with sulphur to form carbon disulphide
(D) Continual electrolysis of liquid acidulated water

Ans : (B)

The vigorous burning of natural gas, which primarily consists of combustible methane, releases significant amounts of heat energy into the surroundings. Chemical reactions that actively release thermal energy are universally classified as exothermic, resulting in products with a lower total energy content.

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34. In the redox reaction represented by $CuO + H_2Cu + H_2O$, which chemical substance is actively getting reduced?
(A) Hydrogen gas
(B) Liquid water
(C) Copper oxide
(D) Pure metallic copper

Ans : (C)

Copper oxide effectively loses its attached oxygen atom to form pure metallic copper during this specific reaction. The direct removal of oxygen precisely defines the reduction process. Therefore, copper oxide is the substance getting reduced, while hydrogen gas is simultaneously oxidized.

35. The table shows the results of mixing different pairs of aqueous solutions. Which mixture provides evidence of a chemical change through the formation of a precipitate?

Mixture ID	Reactant 1	Reactant 2	Final Observation
A	Sodium Chloride	Sugar	A clear solution remains.
B	Lead(II) Nitrate	Potassium Iodide	A yellow solid is formed.
C	Hydrochloric Acid	Sodium Hydroxide	A clear solution forms and the test tube feels warm.
D	Water	Ethanol	A clear solution remains.

(A) Mixture A
(B) Mixture B
(C) Mixture C
(D) Mixture D

Ans : (B)

A precipitation reaction is a chemical change where an insoluble solid (precipitate) is formed upon mixing two solutions. In Mixture B, the formation of a yellow solid (lead iodide) is a clear indication of such a reaction. Mixture C is a neutralisation reaction, while A and D are simple physical mixing processes.

36. Which descriptive statement precisely characterizes the fundamental thermodynamic nature of an endothermic chemical reaction?
(A) The reaction actively releases heat, significantly increasing the surrounding ambient temperature.
(B) The final total energy of the reaction products is strictly greater than that of the reactants.
(C) The chemical change is invariably accompanied by the bright emission of visible light.
(D) The newly formed chemical bonds release substantially more energy than the broken bonds.

Ans : (B)

In a standard endothermic reaction, heat energy is actively absorbed from the surrounding environment, typically causing a measurable decrease in local temperature. Because thermal energy continuously enters the reacting system, the final total energy content of the products is greater than the reactants.

37. The natural biological process of photosynthesis is an excellent textbook example of which specific type of chemical reaction?
(A) Exothermic reaction
(B) Electrochemical reaction
(C) Photochemical reaction
(D) Neutralisation reaction

Ans : (C)

Photosynthesis is a naturally occurring photochemical reaction where living green plants absorb radiant light energy from the sun to convert ambient carbon dioxide and water into complex glucose and life-sustaining oxygen. Since it strictly requires light energy, it is an endothermic photochemical process.

38. According to the established electrochemical activity series, which designated non-metal is considered the most chemically reactive?
(A) Fluorine
(B) Chlorine
(C) Bromine
(D) Iodine

Ans : (A)

The standard activity series meticulously ranks chemical elements based strictly on their relative chemical reactivity. Among the primary non-metals listed in the electrochemical series, fluorine holds the absolute highest position, making it the most intensely reactive non-metal capable of displacing other halogens.

39. What characteristic physical and chemical changes occur when zinc carbonate is strongly heated in a laboratory test tube?

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(A) It melts and rapidly decomposes to give zinc nitrite and oxygen.
(B) It forms a yellow residue when extremely hot, turning pure white upon cooling.
(C) It sublimates completely into the air, leaving absolutely no solid residue behind.
(D) It decomposes completely to yield pure zinc metal, carbon dioxide, and oxygen.

Ans : (B)

Upon strong heating, zinc carbonate undergoes rapid thermal decomposition to successfully release carbon dioxide gas, leaving behind a solid residue of zinc oxide. This specific chemical residue exhibits a distinct physical characteristic it appears visibly yellow while hot and turns completely white once cooled.

40. Read the following detailed statements about the thermal decomposition of various solid metal nitrates

I. Potassium nitrate melts and decomposes to actively give metal nitrite and oxygen gas.
II. Lead nitrate cleanly decomposes to successfully give metal oxide, nitrogen dioxide, and oxygen.
III. Silver nitrate completely decomposes to uniquely yield pure silver metal, nitrogen dioxide, and oxygen.
IV. Sodium nitrate readily decomposes to eventually form solid metal oxide and carbon dioxide gas.

Which of the given statements are correct?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (A)

Sodium and potassium nitrates melt and fundamentally decompose to form soluble nitrites and oxygen gas, strictly not metal oxides. Lead and copper nitrates predictably decompose to form corresponding oxides, nitrogen dioxide, and oxygen. Silver nitrate uniquely yields pure metallic silver, nitrogen dioxide, and oxygen upon heating.

41. During an aqueous neutralisation reaction, which two common chemical ions actively combine to form stable, un-ionised water?
(A) Hydrogen ions and chloride ions
(B) Sodium ions and hydroxyl ions
(C) Hydrogen ions and hydroxyl ions
(D) Sodium ions and chloride ions

Ans : (C)

In a standard aqueous neutralisation reaction occurring strictly between an acid and a base, the primary active chemical change is exclusively the direct combination of positively charged hydrogen ions from the acid with negatively charged hydroxyl ions from the base to form un-ionised water.

42. The table shows the products from heating various metal nitrates. Based on the established trend, identify the correct set of products represented by X, Y, and Z for the decomposition of copper(II) nitrate.

Nitrate Salt	**Products on Heating**
$2KNO_3$	$2KNO_2 + O_2$
$2Cu(NO_3)_2$	X + Y + Z
$2AgNO_3$	$2Ag + 2NO_2 + O_2$

(A) Cu, NO, O_2
(B) CuO, N_2, O_2
(C) 2CuO, $4NO_2$, O_2
(D) $Cu(NO_2)_2$, O_2

Ans : (C)

The thermal decomposition of metal nitrates depends on the metal's position in the activity series. Nitrates of moderately reactive metals like copper (which lies between potassium and silver) decompose on heating to yield the metal oxide, nitrogen dioxide gas, and oxygen gas. The balanced equation is $2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$.

43. When a few solid pieces of zinc are added to a blue copper sulphate solution, the resulting solution eventually turns
(A) Deep green
(B) Bright red
(C) Completely colourless
(D) Vibrant orange

Ans : (C)

Zinc is significantly more chemically reactive than copper. When added directly to a blue copper sulphate solution, zinc rapidly displaces the copper, readily forming highly soluble zinc sulphate. Because aqueous zinc sulphate is inherently colourless, the initially blue solution gradually fades and becomes entirely colourless.

44. What fundamentally and universally occurs to chemical bonds during the progression of any valid chemical reaction?
(A) Only new bonds are freshly formed without breaking any old ones.

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(B) Old bonds are forcefully broken and new chemical bonds are subsequently formed.
(C) Bonds simply stretch considerably without truly breaking or completely reforming.
(D) All existing original chemical bonds are permanently and irrevocably destroyed forever.

Ans : (B)

A true chemical reaction is fundamentally defined as an active process that involves the forceful breaking of existing chemical bonds within the initial reacting substances and the simultaneous making of entirely new bonds to successfully form distinct new substances with vastly different chemical properties.

45. How is a dynamic, reversible chemical reaction conventionally and accurately indicated within a standardized written chemical equation?
(A) By a single straight arrow pointing directly right
(B) By a standard mathematical equal to sign
(C) By a double half-arrow sign (⇌) between reactants and products
(D) By a distinct downward pointing vertical arrow

Ans : (C)

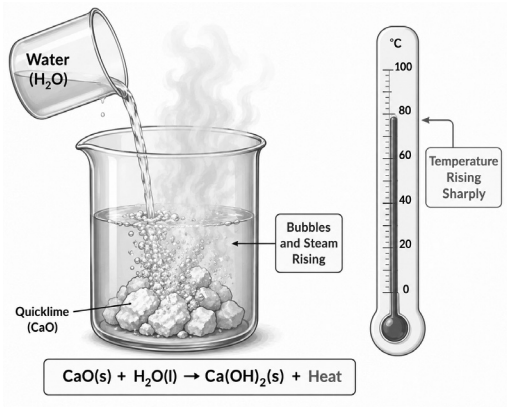
A reversible reaction is one where the forward direction of chemical change can be completely reversed by deliberately altering specific external conditions. To accurately represent this dynamic equilibrium state within a chemical equation, scientists universally place a double half-arrow sign (⇌) between the reactants and products.

46. Why is the common industrial process of slaking quicklime accurately considered to be a highly exothermic chemical reaction?
(A) It continuously absorbs heat energy, noticeably cooling the reaction container.
(B) It essentially requires intense, continuous external heating to proceed properly.
(C) It produces a loud hissing sound and actively releases a tremendous amount of heat.
(D) It inherently requires the continuous and sustained absorption of intense light energy.

Ans : (C)

When liquid water is added directly to solid quicklime, an extremely vigorous chemical reaction rapidly occurs, producing alkaline calcium hydroxide, commonly known as slaked lime. This specific, highly active reaction releases a tremendous amount of heat energy, causing the surrounding water to literally boil while hissing.

47. The process illustrated is the addition of water to quicklime, resulting in a temperature increase. This evidence indicates that the reaction is:



(A) Endothermic, because heat is required to boil the water.
(B) Exothermic, because heat energy is liberated into the surroundings.
(C) A neutralisation reaction, because an acid and a base are mixed.
(D) Reversible, because the steam can be condensed back to water.

Ans : (B)

(A) exothermic reaction is a chemical process that releases energy, typically as heat, causing the temperature of the system and its surroundings to increase. The reaction of quicklime (calcium oxide) with water to form slaked lime is highly exothermic, as demonstrated by the production of steam and the significant rise in temperature.

48. What is the distinct colour of the remaining solid residue left after strongly heating orange-coloured ammonium dichromate?
(A) Pure white
(B) Bright yellow
(C) Dark green
(D) Deep black

Ans : (C)

Heating orange-coloured ammonium dichromate immediately triggers a highly vigorous decomposition reaction chemically characterized by bright flashes. It rapidly releases water vapour and nitrogen gas, leaving behind a stable, dark green-coloured solid residue of chromium oxide in the test tube, signifying a permanent chemical change.

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49. Which of the following highly specific chemical decomposition processes strictly requires the continuous absorption of acoustic sound energy to proceed?

(A) Photochemical decomposition of solid silver chloride
(B) Breakdown of gaseous acetylene directly into carbon and hydrogen
(C) High-pressure synthesis of ammonia from gaseous nitrogen and hydrogen
(D) Intense electrolytic decomposition of molten liquid sodium chloride

Ans : (B)

Certain highly unique chemical reactions strictly require specialized mechanical energy to proceed. For example, reactive acetylene gas can be effectively broken down into solid carbon and gaseous hydrogen exclusively by absorbing sufficient acoustic sound energy, successfully highlighting a notably rare condition necessary for initiating chemical change.

50. The reactivity of halogens is investigated by adding them to solutions of halide salts. Based on the trend observed in the first two experiments, what is the expected observation for 'P'?

Experiment	**Salt Solution**	**Halogen Added**	**Final Solution Colour**
1	2KBr (aq) (colourless)	Cl_2 (g)	Turns yellowish-brown (Br_2 forms)
2	2KI (aq) (colourless)	Br_2 (aq)	Turns brown (I_2 forms)
3	2KCl (aq) (colourless)	Br_2 (aq)	P

(A) Turns yellowish-brown
(B) Turns brown
(C) Solution remains colourless
(D) A white precipitate forms

Ans :(C)

The halogen reactivity series is F > Cl > Br > I. A more reactive halogen displaces a less reactive one from its salt solution. In Experiment 3, a less reactive halogen (bromine) is added to the salt solution of a more reactive halogen (chlorine). Therefore, no displacement reaction will occur, and the solution will remain colourless.

51. Consider the following specific statements regarding observable changes in physical matter

I. Burning of a wax candle firmly involves both distinct physical and chemical changes.
II. Dissolving common sugar in liquid water is a chemical change because a solution is formed.
III. Biological digestion of consumed food is fundamentally considered an irreversible chemical change.
IV. Freezing of liquid water inherently involves a permanent net change in total physical mass.

Which of the given statements are correct?

(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

Ans : (B)

Burning a candle melts solid wax physically while the heated wick burns chemically. Biological digestion chemically breaks down complex food entirely irreversibly. Dissolving sugar is merely a reversible physical change, and freezing water involves an energy change but strictly no permanent change in total physical mass.

52. Consider the following specific statements defining the modern and classical concepts of oxidation and reduction

I. Oxidation involves the direct addition of oxygen or the active removal of hydrogen.
II. Reduction fundamentally involves the total loss of negatively charged electrons by an atom or ion.
III. An oxidizing agent actively oxidizes another substance while simultaneously and inherently getting oxidized itself.
IV. Hydrogen sulphide actively acts as a reducing agent when properly reacting with chlorine gas.

Which of the given statements are incorrect?

(A) I and III
(B) II and III
(C) I and IV
(D) II and IV

Ans : (B)

Reduction is strictly defined by the direct gain of electrons, not their loss. Furthermore, an oxidizing agent inherently gets reduced, not oxidized. Hydrogen sulphide acts exclusively as a reducing agent because it provides hydrogen and effectively reduces chlorine to hydrogen chloride, while simultaneously being actively oxidized.

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53. Consider the following established chemical reaction equations

I. $2KClO_3 \rightarrow 2KCl + 3O_2$

II. $CaO + H_2O \rightarrow Ca(OH)_2$

III. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

IV. $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

Which of the following correctly pairs the specific chemical reaction with its fundamental type?

(A) I - Decomposition, II - Combination
(B) I - Displacement, III - Decomposition
(C) II - Displacement, IV - Combination
(D) III - Double Decomposition, IV - Displacement

Ans : (A)

Reaction I clearly shows a single compound breaking down, representing thermal decomposition. Reaction II involves exactly two compounds combining directly into one, accurately defining a combination reaction. Reaction III is clearly a single displacement, and reaction IV perfectly represents a double decomposition precipitation chemical change.

54. A student records the details of a double decomposition reaction where an insoluble product is formed. Identify the correct chemical formula for the insoluble product 'P'.

Reactants	**Cations Present**	**Anions Present**	**Insoluble Product**
$BaCl_2(aq) + Na_2SO_4(aq)$	Ba^{2+}, Na^+	Cl^-, SO_4^{2-}	$BaSO_4$
$AgNO_3(aq) + NaCl(aq)$	Ag^+, Na^+	NO_3^-, Cl^-	P

(A) $NaNO_3$
(B) AgCl
(C) AgNa
(D) $ClNO_3$

Ans : (B)

In a double decomposition reaction, the cations and anions of the reactants exchange partners. The cation from the first reactant (Ag^+) combines with the anion from the second reactant (Cl^-) to form a new compound. The product, silver chloride (AgCl), is known to be an insoluble white precipitate, matching the context of the reaction type.

55. Evaluate the following descriptive statements regarding the fundamental thermodynamic energy changes in chemical reactions

I. Exothermic reactions involve a significant net release of heat energy directly into the surroundings.

II. Cellular biological respiration is fundamentally characterized as a biochemical endothermic process.

III. Endothermic reactions result in synthesized products possessing a greater total energy content than the reactants.

IV. Common thermal decomposition reactions are almost entirely and typically highly exothermic by nature.

Which of the given statements are correct?

(A) I and III
(B) I and IV
(C) II and III
(D) II and IV

Ans : (A)

Exothermic reactions consistently release thermal energy, whereas endothermic reactions actively absorb it. Consequently, newly formed products of endothermic reactions intrinsically possess higher overall energy content. Biological respiration is highly exothermic, continually releasing vital life energy. Conversely, thermal decomposition reactions usually absorb significant heat energy, maintaining endothermic processes.

56. Match the specific chemical reactions listed in List–I with the corresponding gases actively evolved in List–II.

List–I (Reaction)

P. Action of dilute HCl on zinc metal

Q. Action of dilute HCl on solid calcium carbonate

R. Intense thermal heating of solid lead nitrate

S. Prolonged exposure of chlorine water to sunlight

List–II (Gas Evolved)

I. Oxygen
II. Nitrogen dioxide
III. Hydrogen
IV. Carbon dioxide

(A) P - III, Q - IV, R - II, S - I
(B) P - III, Q - IV, R - I, S - II
(C) P - IV, Q - III, R - II, S - I
(D) P - IV, Q - I, R - II, S - III

Ans : (A)

Zinc quickly reacts with dilute acids to actively displace highly combustible hydrogen gas. Any acid successfully reacting with a carbonate compound consistently liberates effervescent

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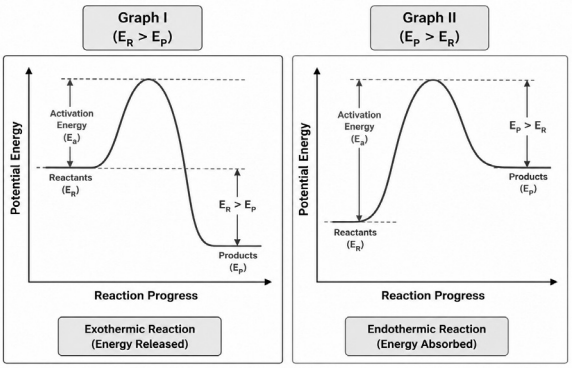
carbon dioxide. Heating solid lead nitrate heavily yields reddish-brown nitrogen dioxide gas, while chlorine water fully exposed to sunlight continuously releases pure oxygen.

57. The graphs show energy profiles for two different reactions. Which interpretation correctly identifies the reaction types ?



(A) Graph I is endothermic; Graph II is exothermic.
(B) Graph I is exothermic; Graph II is endothermic.
(C) Both graphs represent exothermic reactions with different activation energies.
(D) Both graphs represent endothermic reactions with different rates.

Ans :(B)

In an exothermic reaction, the reactants release energy, so the products have lower potential energy than the reactants ($E_P < E_R$), as shown in Graph I. In an endothermic reaction, the reactants absorb energy, so the products have a higher potential energy than the reactants ($E_P > E_R$), as shown in Graph II.

58. Match the actively interacting aqueous chemical solutions provided in List–I with the distinct visible colour of the precipitate formed in List–II.
List–I (Interacting Solutions)
P. Barium chloride + Sodium sulphate
Q. Ferrous sulphate + Sodium hydroxide
R. Silver nitrate + Sodium chloride
S. Lead nitrate + Potassium iodide
List–II (Precipitate Colour)
I. Brilliant yellow
II. Curdy white
III. Dirty green
IV. Plain white
(A) P - IV, Q - III, R - II, S - I
(B) P - II, Q - III, R - IV, S - I
(C) P - IV, Q - II, R - III, S - I
(D) P - I, Q - III, R - IV, S - II

Ans : (A)

Barium sulphate consistently precipitates as a distinctly plain white solid. Ferrous hydroxide notoriously and rapidly forms a highly characteristic dirty green precipitate. Silver chloride distinctively appears as an insoluble curdy white precipitate. Lead iodide consistently settles rapidly out of an aqueous solution as a brilliant yellow precipitate.

59. A partial activity series is provided. If strips of zinc, silver, and lead are placed in separate beakers containing a blue solution of copper(II) sulphate, which beaker will show the formation of a reddish-brown deposit of copper?

Metal	**Reactivity**
Zinc (Zn)	High
Lead (Pb)	Medium
Copper (Cu)	(Reference)
Silver (Ag)	Low

(A) Only the beaker with silver.
(B) Only the beakers with zinc and lead.
(C) Only the beaker with zinc.
(D) All three beakers will show a deposit.

Ans :(B)

A displacement reaction occurs when a more reactive metal displaces a less reactive metal from its salt solution. According to the table, both zinc and lead are more reactive than copper. Therefore, they will displace copper from the copper(II) sulphate solution, forming a reddish-brown deposit of copper metal. Silver is less reactive and will not react.

60. **Assertion (A) :** The simple transition of melting solid ice into liquid water is strictly considered a physical change.
Reason (R) : During the melting of ice, the internal chemical composition fundamentally changes from solid H_2O directly into liquid H_2O_2.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The stated assertion correctly identifies that completely melting ice is fundamentally a physical change because it is entirely physical and reversible. However, the reason is completely

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false because the internal chemical composition strictly remains H_2O throughout the phase transition and absolutely never actively forms hydrogen peroxide.

61. The thermal stability of several metal carbonates is investigated. The metal's position in the reactivity series is provided as a reference. Predict the observation for 'Y'.

Carbonate	Metal Reactivity	Observation on Strong Heating
Na_2CO_3	High	Stable, does not decompose
$CaCO_3$	Medium	Decomposes to metal oxide and carbon dioxide
$ZnCO_3$	Medium	Y
Ag_2CO_3	Low	Decomposes to metal, carbon dioxide and oxygen

(A) Stable, does not decompose
(B) Decomposes to metal oxide and carbon dioxide
(C) Decomposes to metal and carbon dioxide
(D) Decomposes to metal nitrite and oxygen

Ans : (B)

The table shows a trend based on metal reactivity. Metals of medium reactivity, like calcium, decompose upon heating to form the corresponding metal oxide and carbon dioxide. Since zinc is also a metal of medium reactivity, its carbonate ($ZnCO_3$) will follow the same pattern, decomposing to form zinc oxide (ZnO) and carbon dioxide (CO_2).

62. **Assertion (A) :** Solid manganese dioxide acts efficiently as a highly positive catalyst in the thermal decomposition of potassium chlorate.
Reason (R) : A standard positive catalyst substantially increases the rate of a chemical reaction without fundamentally getting consumed itself.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The assertion is true; intentionally adding manganese dioxide significantly lowers the required decomposition temperature of potassium chlorate from roughly 700°C to 300°C. The reason accurately defines a standard positive catalyst and perfectly explains why manganese dioxide effectively increases this specific chemical reaction rate without disappearing entirely.

63. **Assertion (A) :** The aqueous reaction strictly between silver nitrate and sodium chloride is perfectly classified as a precipitation reaction.
Reason (R) : It fundamentally involves an exchange of ions forming a completely insoluble solid product chemically called silver chloride.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The assertion accurately and correctly identifies the interaction as a standard double decomposition precipitation reaction. The reason expertly provides the flawless chemical by correctly stating that exchanging internal ions successfully produces aqueous sodium nitrate alongside a dense, totally insoluble, curdy white solid precipitate consisting of silver chloride.

64. **Assertion (A) :** In the chemical redox reaction specifically between copper oxide and hydrogen, the hydrogen accurately acts as a reducing agent.
Reason (R) : The reactive hydrogen directly adds oxygen to itself to successfully form water, thus forcefully oxidizing the copper oxide.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

The given assertion is true because gaseous hydrogen effectively reduces solid copper oxide completely to elemental copper metal. However, the reason is entirely false; hydrogen aggressively removes oxygen directly from copper oxide rather than actively oxidizing it. By completely removing oxygen, hydrogen acts perfectly as a reducing agent.

65. Using the provided activity series, predict the outcome when an iron nail is placed in copper(II) sulphate solution and a copper wire is placed in zinc sulphate solution.

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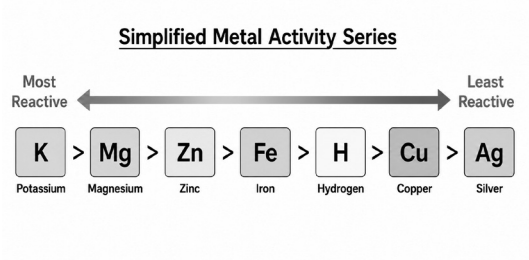

(A) A reaction will occur in both beakers.
(B) No reaction will occur in either beaker.
(C) A reaction will occur only with the iron nail in the copper(II) sulphate solution.
(D) A reaction will occur only with the copper wire in the zinc sulphate solution.

Ans : (C)

A displacement reaction occurs only if a more reactive metal is placed in the salt solution of a less reactive metal. According to the series, iron (Fe) is more reactive than copper (Cu), so it will displace copper. However, copper (Cu) is less reactive than zinc (Zn), so it cannot displace zinc from its salt solution.

66. **Assertion (A) :** The standard aqueous neutralisation reaction strictly between sodium hydroxide and hydrochloric acid is classified as an endothermic process.
Reason (R) : Endothermic reactions constantly and actively absorb heat energy from the surrounding environment, strictly resulting in a temperature drop.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (D)

The assertion is inherently false because absolutely all standard neutralisation reactions are fundamentally and universally exothermic, meaning they constantly and actively release substantial heat energy. Conversely, the reason statement is factually true, as it correctly defines the exact physical characteristics of any standard endothermic chemical reaction process.

67. Which of the following specific metal carbonates is highly stable to intense heating and remains completely soluble in liquid water?
(A) Zinc carbonate
(B) Calcium carbonate
(C) Magnesium carbonate
(D) Potassium carbonate

Ans : (D)

The inherent thermal stability of metal carbonates strongly depends on the specific metal's overall reactivity. Alkali metals like sodium and potassium are highly reactive, effectively making their carbonates entirely stable to prolonged heating. Furthermore, unlike most heavy metal carbonates, potassium carbonate safely remains highly water-soluble.

68. In the laboratory experiment actively demonstrating thermal dissociation, what specific chemical sublimate is safely formed on the colder upper side of the test tube when solid ammonium chloride is heavily heated?
(A) Pure ammonia gas
(B) Hydrogen chloride gas
(C) Solid ammonium chloride
(D) Pure nitrogen gas

Ans : (C)

When solid ammonium chloride is heavily heated, it readily undergoes thermal dissociation directly into gaseous ammonia and hydrogen chloride. As these hot reacting gases quickly rise and reach the significantly colder upper section of the vertical test tube, they rapidly recombine to safely deposit a solid white ammonium chloride sublimate.

69. Which specific chemical gas is rapidly evolved when dilute sulphuric acid is slowly added directly to solid iron (II) sulphide?
(A) Pungent sulphur dioxide
(B) Hydrogen sulphide
(C) Pure oxygen
(D) Brown nitrogen dioxide

Ans : (B)

Carefully adding dilute sulphuric acid directly to solid iron (II) sulphide immediately results in a highly visible double decomposition reaction. The metallic and acidic chemical radicals readily exchange their respective places to successfully form highly soluble iron (II) sulphate and actively evolve hydrogen sulphide, a toxic gas characterized by a pungent, rotten-egg odour.

ONE MARK QUESTIONS

70. Write any two conditions for a chemical change.

Ans :

Temperature, pressure.

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71. What would happened on burning if the proportions of nitrogen and oxygen in the air were reversed.

Ans :

The process of combustion would be rapid and uncontrollable.

72. Name the natural process by which oxygen is removed and carbon dioxide is produced in the atmosphere.

Ans :

Respiration

73. Name the natural process by which oxygen is added and carbon dioxide is removed from the atmosphere.

Ans :

Photosynthesis

74. What is a promoter?

Ans :

The substance which increases the rate of a reaction.

75. The rate of a chemical reaction is more when temperature increases. Justify.

Ans :

With increase in temperature, the kinetic energy increases, and therefore, the number of collisions increases resulting in increase in chemical reaction.

76. State the type of chemical reactions of the following:

(i) $2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$

(ii) $C + O_2 \xrightarrow{\Delta} CO_2$

(iii) $2CO + O_2 \xrightarrow{\Delta} 2CO_2$

(iv) $CuCO_3 \xrightarrow{\Delta} CuO + CO_2$

(v) $NH_4Cl \underset{\text{Cool}}{\overset{\Delta}{\rightleftharpoons}} NH_3 + HCl$

Ans :

(i) Thermal decomposition reaction
(ii) Synthesis
(iii) Direct combination
(iv) Thermal decomposition
(v) Thermal dissociation

77. Match the following:

	Column I		**Column II**
(i)	Interchange of radicals	(a)	Direct combination
(ii)	Combination of only elements	(b)	Neutralization
(iii)	Combination of elements and compounds	(c)	Double decomposition
(iv)	Reaction for the formation of soluble salts	(d)	Precipitation
(v)	Reaction for the formation of insoluble salts	(e)	Synthesis

Ans :

	Column I		**Column II**
(i)	Interchange of radicals	(c)	Double decomposition
(ii)	Combination of only elements	(e)	Synthesis
(iii)	Combination of elements and compounds	(a)	Direct combination
(iv)	Reaction for the formation of soluble salts	(b)	Neutralization
(v)	Reaction for the formation of insoluble salts	(d)	Precipitation

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DIRECTION : Complete the following equation :

78. Complete and balance the following equations

(i) $N_2 + O_2 \longrightarrow$ (ii) $NO + O_2 \longrightarrow$

(iii) $S + O_2 \longrightarrow$ (iv) $SO_3 + H_2O \longrightarrow$

(v) $KNO_3 \xrightarrow{\Delta}$ (vi) $NaNO_3 \xrightarrow{\Delta}$

(vii) $Ca(NO_3)_2 \xrightarrow{\Delta}$ (viii) $AgNO_3 \xrightarrow{\Delta}$

(ix) $Cu(OH)_2 \xrightarrow{\Delta}$ (x) $Pb_3O_4 \xrightarrow{\Delta}$

(xi) $PbO_2 \xrightarrow{\Delta}$ (xii) $HgO \xrightarrow{\Delta}$

(xiii) $Ag_2O \xrightarrow{\Delta}$ (xiv) $PCl_5 \underset{\text{Cool}}{\overset{\Delta}{\rightleftharpoons}}$

(xv) $Pb(NO_3)_2 + NaCl \rightarrow$

Ans :

(i) $N_2 + O_2 \longrightarrow 2NO$

(ii) $2NO + O_2 \longrightarrow 2NO_2$

(iii) $S + O_2 \longrightarrow SO_2$

$2S + 3O_2 \longrightarrow 2SO_3$

(iv) $SO_3 + H_2O \longrightarrow H_2SO_4$

(v) $2KNO_3 \xrightarrow{\Delta} 2KNO_2 + O_2$

(vi) $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$

(vii) $2Ca(NO_3)_2 \xrightarrow{\Delta} 2CaO + 4NO_2 + O_2$

(viii) $2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

(ix) $Cu(OH)_2 \xrightarrow{\Delta} CuO + H_2O$

(x) $2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$

(xi) $2PbO_2 \xrightarrow{\Delta} 2PbO + O_2$

(xii) $2HgO \xrightarrow{\Delta} 2Hg + O_2$

(xiii) $2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$

(xiv) $PCl_5 \underset{\text{Cool}}{\overset{\Delta}{\rightleftharpoons}} PCl_3 + Cl_2$

(xv) $Pb(NO_3)_2 + 2NaCl \longrightarrow PbCl_2 + 2NaNO_3$

79. Complete the following equations:

(i) $Cu(NO_3)_2 + NaOH \longrightarrow$

(ii) $Pb(NO_3)_2 + KI \longrightarrow$

(iii) $Pb(NO_3)_2 + HCl \longrightarrow$

(iv) $Pb(NO_3)_2 + Na_2CO_3 \longrightarrow$

(v) $Pb(NO_3)_2 + Na_2SO_4 \longrightarrow$

(vi) $BaCl_2 + Na_2SO_4 \longrightarrow$

(vii) $MgSO_4 + NaOH \longrightarrow$

(viii) $FeCl_3 + NaOH \longrightarrow$

(ix) $FeCl_2 + NaOH \longrightarrow$

(x) $CuSO_4 + Fe \longrightarrow$

(xi) $KBr + Cl_2 \longrightarrow$

(xii) $Fe + HCl \longrightarrow$

(xiii) $Fe + H_2SO_4 \longrightarrow$

(xiv) $Fe + S \longrightarrow$

(xv) $Mg + H_2SO_4 \longrightarrow$

Ans :

(i) $Cu(NO_3)_2 + 2NaOH \longrightarrow Cu(OH)_2 + 2NaNO_3$

(ii) $Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3$

(iii) $Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 + 2HNO_3$

(iv) $Pb(NO_3)_2 + Na_2CO_3 \longrightarrow PbCO_3 + 2NaNO_3$

(v) $Pb(NO_3)_2 + Na_2SO_4 \longrightarrow PbSO_4 + 2NaNO_3$

(vi) $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$

(vii) $MgSO_4 + 2NaOH \longrightarrow Mg(OH)_2 + Na_2SO_4$

(viii) $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 + 3NaCl$

(ix) $FeCl_2 + 2NaOH \longrightarrow Fe(OH)_2 + 2NaCl$

(x) $CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$

(xi) $2KBr + Cl_2 \longrightarrow 2KCl + Br_2$

(xii) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$

(xiii) $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$

(xiv) $Fe + S \xrightarrow{\Delta} FeS$

(xv) $Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$

80. State which of the following are oxidized or reduced.

(i) $S^{2-} \longrightarrow S$

(ii) $Cl^- \longrightarrow Cl$

(iii) $Mn^{5+} \longrightarrow Mn^{7+}$

(iv) $Cl_2 \longrightarrow Cl^-$

(v) $Cr^{7+} \longrightarrow Cr^{5+}$

Ans :

(i) $S^{2-} \longrightarrow S$

$S^{2-} - 2e^- \longrightarrow S$ (Oxidation)

(ii) $Cl^- \longrightarrow Cl$

$Cl^- - e^- \longrightarrow Cl$ (Oxidation)

(iii) $Mn^{5+} \longrightarrow Mn^{7+}$

$Mn^{5+} - 2e^- \longrightarrow Mn^{7+}$ (Oxidation)

(iv) $Cl_2 \longrightarrow Cl^-$

$Cl_2 + 2e^- \longrightarrow 2Cl^-$ (Reduction)

(v) $Cr^{7+} \longrightarrow Cr^{5+}$

$Cr^{7+} + 2e^- \longrightarrow Cr^{5+}$ (Reduction)

81. Complete and balance the following equations.

(i) $2Al + 6HCl \longrightarrow$ _____ + _____

(ii) $CuSO_4 + Fe \longrightarrow$ _____ + _____

(iii) $NH_4NO_3 \xrightarrow{\Delta}$ _____ + _____

(iv) $AgNO_3 \xrightarrow{\Delta}$ _____ + _____ + _____

(v) $Pb_3O_4 \xrightarrow{\Delta}$ _____ + _____

(vi) $N_2 + O_2 \longrightarrow$ _____

(vii) $CuCO_3 \xrightarrow{\Delta}$ _____ + _____

(viii) $NaNO_3 \xrightarrow{\Delta}$ _____ + _____

(ix) $CO + O_2 \longrightarrow$ _____

(x) $P_2O_5 + H_2O \longrightarrow$ _____

Ans :

(i) $2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

(ii) $CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$

(iii) $NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$

(iv) $2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

(v) $2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$

(vi) $N_2 + O_2 \longrightarrow 2NO$

(vii) $CuCO_3 \xrightarrow{\Delta} CuO + CO_2$

(viii) $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$

(ix) $2CO + O_2 \longrightarrow 2CO_2$

(x) $P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$

DIRECTION : Fill in the blanks

82. Fill in the blanks:

(i) Oxidation is the process of _____ of electrons.

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(ii) Reduction is the process of _____ of electrons
(iii) Reducing agents are electron _____.
(iv) Oxidizing agents are electron _____.
(v) Metals are _____ agents.
(vi) Non-metals are _____ agents.

Ans :
(i) loss
(ii) gain
(iii) donors
(iv) acceptors
(v) reducing
(vi) oxidising.

83. Fill in the blanks.
(i) Heating of camphor is a _____ change, whereas the burning of camphor is a _____ change.
(ii) A reversible thermal decomposition reaction is called thermal _____ reaction.
(iii) During exothermic reaction energy is _____.
(iv) _____ is the process of loss of electrons.
(v) _____ is the process of gain of electrons.
(vi) Reducing agents are electron _____.
(vii) Oxidizing agents are electron _____.
(viii) _____ are reducing agents.
(ix) _____ are oxidizing agents.
(x) Heating of zinc oxide is a _____ change.

Ans :
(i) physical, chemical
(ii) dissociation
(iii) released
(iv) Oxidation
(v) Reduction
(vi) donors
(vii) acceptors
(viii) Metals
(ix) Non-metals
(x) physical

84. Fill in the blanks.
(i) A substance which increases the efficiency of a catalyst is known as _____.
(ii) The reactions which take place in the presence of light are called _____ raction.
(iii) Petrol, LPG and kerosene are _____ substances.
(iv) Curdling of milk is an example of _____ change.
(v) _____ of metals is a list of metals in the order of their decreasing chemical activity.

Ans :
(i) promoter
(ii) photochemical
(iii) inflammable
(iv) chemical
(v) Activity series

85. Name the reducing agent in the following reactions:
(i) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
(ii) $CuO + H_2 \longrightarrow Cu + H_2O$
(iii) $ZnO + C \longrightarrow Zn + CO$
(iv) $3CuO + 2NH_3 \longrightarrow 3Cu + N_2 + 3H_2O$
(v) $PbO + C \longrightarrow Pb + CO$

Ans :
(i) Carbon monoxide, CO
(ii) Hydrogen
(iii) Carbon
(iv) Ammonia
(v) Carbon

DIRECTION : Name the following :

86. Name the following.
(i) Gas liberated when ammonium nitrate is heated.
(ii) Two stable metallic hydroxides.
(iii) Two metals which does not react with oxygen.
(iv) Two metals which directly combine with sulphur on heating.
(v) Two metals which directly combine with nitrogen on heating.

Ans :
(i) Nitrous oxide
(ii) NaOH and KOH
(iii) Silver and gold
(iv) Iron and Zinc
(v) Calcium and Magnesium

87. Complete the following. Also, balance them.
(i) $Ca + O_2 \longrightarrow \underset{\text{(Lime)}}{\_\_\_\_} + H_2O \longrightarrow \underset{\text{(Slaked lime)}}{\_\_\_\_}$
(ii) $K + O_2 \longrightarrow \underset{\text{(Potassium oxide)}}{\_\_\_\_} + H_2O \longrightarrow \underset{\text{(Caustic potash)}}{\_\_\_\_}$
(iii) $2H_2O \xrightarrow[\text{Current}]{\text{Electric}} \underset{\text{(Hydrogen)}}{\_\_\_\_} + O_2$
(iv) $NH_4Cl \longrightarrow \underset{\text{(Ammonia)}}{\_\_\_\_} + HCl$

Ans :
(i) $2Ca + O_2 \longrightarrow \underset{\text{(Lime)}}{2CaO} + 2H_2O \longrightarrow \underset{\text{(Slaked lime)}}{2Ca(OH)_2}$

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(ii) $4K + O_2 \longrightarrow \underset{\text{(Potassium oxide)}}{2K_2O} + 2H_2O \longrightarrow \underset{\text{(Caustic potash)}}{4KOH}$

(iii) $2H_2O \xrightarrow[\text{Current}]{\text{Electric}} \underset{\text{Hydrogen}}{2H_2} + O_2$

(iv) $NH_4Cl \longrightarrow \underset{\text{Ammonia}}{NH_3} + HCl$

88. State whether the following statements are True or False.

(i) During endothermic reaction heat is liberated.

(ii) During chemical change always a new product is formed.

(iii) Rancidification of butter is a chemical change.

(iv) Sodium nitrate is stable towards heat.

(v) Neutralization is a type of double decomposition reaction.

Ans :

(i) False (ii) True (iii) True

(iv) False (v) True

89. State the type of chemical reactions:

(i) $N_2 + O_2 \longrightarrow 2NO$

(ii) $2NO + O_2 \longrightarrow 2NO_2$

(iii) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$

(iv) $KOH + HNO_3 \longrightarrow KNO_3 + H_2O$

(v) $FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2 + Na_2SO_4$

Ans :

(i) Synthesis

(ii) Direct combination

(iii) Simple displacement

(iv) Neutralization

(v) Precipitation

90. State which of the following are oxidized or reduced.
(Write equation for the electron transfer also)

(i) $Cu \longrightarrow Cu^{2+}$

(ii) $O^{2-} \longrightarrow O_2$

(iii) $Cl_2 \longrightarrow Cl^-$

(iv) $Fe \longrightarrow Fe^{2+}$

(v) $S \longrightarrow S^{2-}$

Ans :

(i) Oxidation $Cu - 2e^- \longrightarrow Cu^{2+}$

(ii) Oxidation $2O^{-2} - 4e^- \longrightarrow O_2$

(iii) Reduction $Cl_2 + 2e^- \longrightarrow 2Cl^{-1}$

(iv) Oxidation $Fe - 2e^- \longrightarrow Fe^{2+}$

(v) Reduction $S + 2e^- \longrightarrow S^{-2}$

91. Give one word:

(i) Chemical reaction in which heat is evolved.

(ii) Reactions which take place in presence of electricity.

(iii) Substance which do not burn in air or oxygen.

(iv) The substance which increases the rate of reaction without itself undergoing any change.

(v) The minimum temperature at which a substance starts burning.

Ans :

(i) Exothermic

(ii) Electrolysis

(iii) Non-combustible

(iv) Catalyst

(v) Ignition temperature

92. Name the following:

(i) Two metallic oxides decompose on heating.

(ii) An oxidizing agent which does not contain oxygen.

(iii) A gas acting both as an oxidizing and reducing agent.

(iv) Two metals which do not react with water.

(v) A metallic carbonate which on heating forms respective metal.

Ans :

(i) Mercuric oxide and silver oxide

(ii) Chlorine

(iii) Sulphur dioxide

(iv) Copper, silver

(v) Silver carbonate

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TWO MARKS QUESTIONS

93. A student burns a piece of paper and observes the formation of ash, heat and light. Why is this a chemical change?

Ans :

(i) New substances are formed.

(ii) The change is irreversible and the composition changes permanently.

94. Why is burning of paper considered an exothermic reaction?

Ans :

(i) Heat energy is released during the reaction.

(ii) Light energy is also produced.

95. During the decomposition of lead nitrate, both physical and chemical changes occur. Give one example of each.

Ans :

(i) Chemical change: Formation of new substances.
(ii) Physical change: Change in colour and state during heating.

96. State any two conditions necessary for a chemical reaction to occur.

Ans :

(i) Effective collision between particles.
(ii) Proper energy and orientation of particles.

97. What is the main difference between a synthesis reaction and a decomposition reaction?

Ans :

(i) In synthesis, two or more substances combine to form one product.
(ii) In decomposition, one compound breaks down into two or more products.

98. Why is the reaction between magnesium and oxygen called a synthesis reaction?

Ans :

(i) Two reactants combine together.
(ii) A single product, magnesium oxide, is formed.

99. A metal oxide reacts with water to form an alkali. What will happen to red litmus paper?

Ans :

(i) The solution formed is basic.
(ii) Red litmus turns blue.

100. Why are non-metallic oxides generally called acidic oxides?

Ans :

(i) They react with water to form acids.
(ii) The acids formed turn blue litmus red.

101. Why are sodium carbonate and potassium carbonate called heat-stable carbonates?

Ans :

(i) They do not decompose on heating.
(ii) Their composition remains unchanged.

102. Why does copper not liberate hydrogen when treated with dilute hydrochloric acid?

Ans :

(i) Copper lies below hydrogen in the activity series.
(ii) Therefore it cannot displace hydrogen from acids.

103. Why is zinc able to displace copper from copper sulphate solution?

Ans :

(i) Zinc is more reactive than copper.
(ii) Zinc lies above copper in the activity series.

104. Why is the reaction between hydrochloric acid and sodium hydroxide called neutralization?

Ans :

(i) An acid reacts with a base.
(ii) Salt and water are formed.

105. What is a precipitate?

Ans :

(i) It is an insoluble solid formed during a reaction.
(ii) It is produced in a precipitation reaction.

106. Why is silver nitrate decomposition considered a photochemical reaction?

Ans :

(i) The reaction occurs in the presence of light.
(ii) Light provides the energy required for decomposition.

107. Why is electrolysis of acidulated water called an electrochemical reaction?

Ans :

(i) The reaction occurs due to electricity.
(ii) Electrical energy causes chemical decomposition.

108. What is meant by ignition temperature?

Ans :

(i) It is the minimum temperature required for a substance to catch fire.
(ii) Combustion cannot start below this temperature.

109. Why is oxygen called a supporter of combustion?

Ans :

(i) It helps substances to burn.
(ii) It is necessary for combustion to occur.

110. In a redox reaction, why must oxidation and reduction occur together?

Ans :

(i) Electrons lost by one substance must be gained by another.

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(ii) Therefore oxidation and reduction occur simultaneously.

111. Why are metals generally considered reducing agents?

Ans :

(i) Metals readily lose electrons.
(ii) By donating electrons, they reduce other substances.

112. Why are non-metals generally considered oxidizing agents?

Ans :

(i) Non-metals readily gain electrons.
(ii) By accepting electrons, they oxidize other substances.

113. What is a photochemical reaction? Give one example.

Ans :

The chemical reaction which takes place in the presence of light is called photochemical reaction. The example is the process of photosynthesis.

114. What is photochemical reaction? Support your answer by two examples.

Ans :

The chemical reactions which proceed in the presence of light are called photochemical reactions. For example, photosynthesis, decomposition of silver nitrates.

115. What are electrochemical reaction? Give two examples.

Ans :

The chemical reactions which proceed in the presence of electricity are called electrochemical reactions, e.g. electrolysis of acidulated water, electrolysis of molten NaCl.

116. What is the difference between precipitation and neutralization reactions? What type of salts are prepared by neutralization and precipitation?

Ans :

In neutralization, the products formed are soluble, whereas during precipitation the products formed are insoluble.
Soluble salts are prepared by neutralization.
Insoluble salts are prepared by precipitation.

117. State whether the following changes are physical or chemical.
(i) Rancidification of butter
(ii) Souring of milk
(iii) Tearing of paper
(iv) Stitching of shirt

Ans :

(i) Chemical
(ii) Chemical
(iii) Physical
(iv) Physical

118. Name the four important types of chemical reactions.

Ans :

(i) Synthesis
(ii) Decomposition
(iii) Displacement
(iv) Double decomposition

119. Give one example each of:
(i) Oxidation (ii) Reduction
(iii) Oxidising agent (iv) Reducing agent

Ans :

(i) $Zn \longrightarrow Zn^{2+} + 2e^-$
(ii) $Fe^{3+} + e^- \longrightarrow Fe^{2+}$
(iii) Non-metals
(iv) Metals

120. When we mix iron filings with sulphur and grind it, a physical change takes place, however if we heat this mixture a chemical change takes place. Justify.

Ans :

On heating powdered iron and sulphur, synthesis reaction takes place

$$Fe + S \xrightarrow{\Delta} FeS$$

But on grinding, no reaction takes place.

121. Explain why heating of ammonium chloride can be said both a physical and a chemical change. Give one more example.

Ans :

Heating of ammonium chloride is an example of reversible thermal decomposition reaction. In this reaction NH_4Cl first weaks down to give NH_3 and HCl gas (chemical) which recombines on the upper cooler surface to again form NH_4Cl (physical).

122. Define
(i) neutralization.
(ii) exothermic reaction.

Ans :

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(i) The reaction in which acid reacts with base to form salt and water as the only products.
(ii) The reaction in which energy is liberated.

123. The burning of a candle is both a physical and a chemical change. Justify the statement.

Ans :

(A) melting of wax takes place first, which is a physical change and then finally wax burns to give CO_2 and water vapour, which is a chemical change.

124. Give reasons:
(a) When ammonium nitrate is dissolved in water, it becomes cold.
(b) Silver nitrate solution is kept in colour reagent bottles in the laboratory.

Ans :

(a) Because the reaction is endothermic.
(b) Silver nitrate is sensitive towards light and it decomposes readily an exposure to light hence, it is stored in dark coloured bottles.

125. Mixing and grinding of iron and sulphur gives a mixture whereas on heating them together forms a compound.
(i) What change has taken place on mixing iron and sulphur?
(ii) What change has taken place on heating iron and sulphur together?

Ans :

(i) Physical change
(ii) Chemical change

126. Define
(i) exothermic reaction.
(ii) endothermic reaction.

Ans :

(i) Exothermic reaction: The reaction in which the energy is liberated is called exothermic reaction.
(ii) Endothermic reaction: The reaction in which the energy is absorbed is called endothermic reaction.

127. State which of the following are oxidized or reduced.
(i) $Fe^{2+} \longrightarrow Fe$
(ii) $Fe^{3+} \longrightarrow Fe^{2+}$
(iii) $O^{2-} \longrightarrow O$
(iv) $Cr^{7+} \longrightarrow Cr^{5+}$

Ans :

(i) Reduced (ii) Reduced
(iii) Oxidized (iv) Reduced

128. Differentiate between:
(i) Reversible and Irreversible reactions.
(ii) Exothermic and endothermic reactions.

Ans :

(i)

	Reversible Reaction		**Irreversible Reaction**
(a)	The reaction which takes place in both the directions	(a)	The reaction which takes place only in one direction is called irreversible reaction.
(b)	Shown by $\rightleftharpoons$ arrow.	(b)	Shown by $\longrightarrow$ arrow.
(c)	These reactions never reach completion.	(c)	These reactions almost reach completion.

(ii)

	Exothermic reaction		**Endothermic reaction**
(a)	Heat is evolved in this reaction.	(a)	Heat is absorbed in this reaction.
(b)	Total energy of reactants is more than product.	(b)	Total energy of reactants is less than product.

THREE MARKS QUESTIONS

129. A student burns magnesium ribbon in air and obtains a white powder.
(a) Name the white powder formed.
(b) What type of reaction is this?
(c) Why is it called so?

Ans :

(a) Magnesium oxide
(b) Synthesis reaction
(c) Magnesium and oxygen combine to form a single product.

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130. Carbon monoxide burns in oxygen to form carbon dioxide.
(a) Name the type of reaction.
(b) Is it exothermic or endothermic?
(c) Give one reason.

Ans :
(a) Direct combination reaction
(b) Exothermic reaction
(c) Heat is released during combustion.

131. A student heats calcium carbonate strongly.
(a) Name the products formed.
(b) What type of reaction occurs?
(c) Why is it classified under this type?

Ans :
(a) Calcium oxide and carbon dioxide
(b) Decomposition reaction
(c) One compound breaks into two simpler substances.

132. Zinc is added to copper sulphate solution.
(a) What change is observed?
(b) Which metal is displaced?
(c) Why does this happen?

Ans :
(a) Blue colour fades and copper is deposited.
(b) Copper is displaced.
(c) Zinc is more reactive than copper.

133. Why does copper not react with dilute hydrochloric acid?

Ans :
(i) Copper lies below hydrogen in the activity series.
(ii) It cannot displace hydrogen from acids.
(iii) Hence no hydrogen gas is evolved.

134. State three conditions necessary for combustion.

Ans :
(i) Presence of oxygen or supporter of combustion.
(ii) Presence of combustible substance.
(iii) Attainment of ignition temperature.

135. Differentiate between exothermic and endothermic reactions with one example each.

Ans :
(i) Exothermic reactions release energy; e.g., burning of coal.
(ii) Endothermic reactions absorb energy; e.g., decomposition of calcium carbonate.
(iii) Energy flow is outward in exothermic and inward in endothermic reactions.

136. A metal oxide reacts with water and forms a solution that turns red litmus blue.
(a) What is the nature of the oxide?
(b) What is formed?
(c) Why does litmus change colour?

Ans :
(a) Basic oxide
(b) Alkali
(c) The solution is basic in nature.

137. Explain why hydrochloric acid and sodium hydroxide reaction is called a neutralization reaction.

Ans :
(i) Hydrochloric acid is an acid and sodium hydroxide is a base.
(ii) They react to form salt and water.
(iii) The acidic and basic properties neutralize each other.

138. A student claims that all decomposition reactions require heat. Do you agree?

Ans :
(i) No.
(ii) Some decomposition reactions occur in the presence of light.
(iii) Others occur in the presence of electricity.

139. Explain why silver nitrate decomposition is called a photochemical reaction.

Ans :
(i) It takes place in the presence of light.
(ii) Light provides the energy required.
(iii) Silver nitrate decomposes into simpler substances.

140. Why is electrolysis of acidulated water considered an electrochemical reaction?

Ans :
(i) Electricity is passed through the solution.
(ii) Water decomposes into hydrogen and oxygen.
(iii) The reaction occurs due to electrical energy.

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141. A student adds sodium hydroxide solution to copper sulphate solution.
(a) What type of reaction occurs?
(b) What is formed?
(c) Why is it called a precipitation reaction?

Ans :

(a) Double decomposition reaction
(b) Copper hydroxide precipitate
(c) An insoluble solid is formed.

142. Explain why oxidation and reduction always occur together.

Ans :

(i) Electrons lost by one substance must be gained by another.
(ii) Oxidation involves loss of electrons.
(iii) Reduction involves gain of electrons.

143. Why are metals generally considered reducing agents?

Ans :

(i) Metals lose electrons easily.
(ii) They donate electrons to other substances.
(iii) Therefore they cause reduction.

144. Why are non-metals generally considered oxidizing agents?

Ans :

(i) Non-metals readily gain electrons.
(ii) They accept electrons from other substances.
(iii) Therefore they cause oxidation.

145. A student observes that potassium reacts violently with water whereas iron reacts only with steam.
Explain this observation.

Ans :

(i) Potassium is more reactive than iron.
(ii) Potassium is higher in the activity series.
(iii) Therefore it reacts readily with cold water.

146. State three observations that indicate a chemical reaction has occurred.

Ans :

(i) Evolution of gas.
(ii) Change in colour.
(iii) Formation of precipitate or release of energy.

147. Why is the reaction between nitrogen and hydrogen in the Haber process considered a synthesis reaction?

Ans :

(i) Nitrogen and hydrogen are reactants.
(ii) They combine chemically.
(iii) A single product, ammonia, is formed.

148. A student places silver in copper sulphate solution and observes no reaction.
Explain the observation.

Ans :

(i) Silver is less reactive than copper.
(ii) Silver lies below copper in the activity series.
(iii) Therefore it cannot displace copper from its salt solution.

149. Give two examples in which physical and chemical changes occur simultaneously.

Ans :

(i) Heating of sodium nitrate

$$2NaNO_3(s) \xrightarrow{\Delta} 2NaNO_3(l)$$

(Physical change)

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$$

(Chemical change)

(ii) Heating of zinc carbonate

$$ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$$

(Chemical change)

$$\underset{\text{white}}{ZnO} \xrightarrow{\Delta} \underset{\text{yellow}}{ZnO}$$

(Physical change)

150. Define the following terms:
(i) Catalyst (ii) Inhibitor (iii) Promoter

Ans :

(i) Catalyst: A substance which alters the rate of chemical reaction but does not take part in a chemical reaction is called a catalyst.
(ii) Inhibitor: A substance which slows down the rate of a reaction is called an inhibitor.
(iii) Promoter: A substance which increases the rate of a reaction by improving the efficiency of a catalyst is called promoter.

151. State the type of chemical reactions.

(i) $2CO + O_2 \longrightarrow 2CO_2$
(ii) $C + O_2 \longrightarrow CO_2$
(iii) $2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$
(iv) $PCl_5 \underset{\text{Cool}}{\overset{\Delta}{\rightleftharpoons}} PCl_3 + Cl_2$
(v) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$
(vi) $NaOH + HCl \longrightarrow NaCl + H_2O$
(vii) $Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2 + 2HNO_3$
(viii) $2KI + Cl_2 \longrightarrow 2KCl + I_2$

Ans :

(i) Direct combination
(ii) Synthesis
(iii) Decomposition

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(iv) Thermal dissociation
(v) Simple displacement
(vi) Neutralization
(vii) Precipitation
(viii) Simple displacement.

FOUR MARKS QUESTIONS

152. A student burns magnesium ribbon in air and obtains a white powder.
(a) Name the white powder formed.
(b) Write the word equation.
(c) Name the type of reaction.
(d) State whether it is exothermic or endothermic.

Ans :
(a) Magnesium oxide
(b) Magnesium + Oxygen → Magnesium oxide
(c) Synthesis reaction
(d) Exothermic reaction

153. Explain the difference between a synthesis reaction and a decomposition reaction with one example of each.

Ans :
(i) In a synthesis reaction, two or more substances combine to form a single product.
(ii) Example: Magnesium + Oxygen → Magnesium oxide.
(iii) In a decomposition reaction, one compound breaks into two or more products.
(iv) Example: Calcium carbonate → Calcium oxide + Carbon dioxide.

154. A student adds zinc granules to copper sulphate solution.
(a) What observation will be made?
(b) Which metal is displaced?
(c) What type of reaction is this?
(d) Why does the reaction occur?

Ans :
(a) The blue colour fades and copper is deposited.
(b) Copper is displaced.
(c) Simple displacement reaction.
(d) Zinc is more reactive than copper.

155. State four differences between exothermic and endothermic reactions.

Ans :

Exothermic Reaction	Endothermic Reaction
Energy is released	Energy is absorbed
Surroundings become warmer	Surroundings become cooler
Example: Combustion	Example: Thermal decomposition
Products have lower energy	Products have higher energy

156. Explain why potassium reacts with cold water while copper does not react with water.

Ans :
(i) Potassium is highly reactive and lies at the top of the activity series.
(ii) Copper is less reactive and lies below hydrogen.
(iii) Potassium displaces hydrogen from water.
(iv) Copper cannot displace hydrogen from water.

157. A metal oxide dissolves in water and the solution turns red litmus blue.
(a) What is the nature of the oxide?
(b) What is formed when it reacts with water?
(c) Why does litmus change colour?
(d) Give one example.

Ans :
(a) Basic oxide
(b) Alkali
(c) The solution is basic.
(d) Sodium oxide + Water → Sodium hydroxide.

158. Explain the neutralization reaction between hydrochloric acid and sodium hydroxide.

Ans :
(i) Hydrochloric acid is an acid.
(ii) Sodium hydroxide is a base.
(iii) They react to form sodium chloride and water.
(iv) The acidic and basic properties neutralize each other.

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159. State four characteristics of a double decomposition reaction.

Ans :
(i) Two compounds react in solution form.
(ii) Exchange of radicals takes place.

(iii) New compounds are formed.
(iv) A precipitate or water may be produced.

160. A student heats calcium carbonate strongly.
(a) Name the products formed.
(b) Classify the reaction.
(c) Is energy absorbed or released?
(d) Give one practical application of this reaction.

Ans :

(a) Calcium oxide and carbon dioxide.
(b) Decomposition reaction.
(c) Energy is absorbed.
(d) Manufacture of quicklime.

161. Explain the role of the activity series in predicting displacement reactions.

Ans :

(i) Metals are arranged according to decreasing reactivity.
(ii) A more reactive metal displaces a less reactive metal.
(iii) Metals above hydrogen displace hydrogen from acids.
(iv) Metals below hydrogen cannot do so.

162. Explain oxidation, reduction and redox reaction with suitable examples.

Ans :

(i) Oxidation is the loss of electrons.
(ii) Reduction is the gain of electrons.
(iii) Redox reaction involves oxidation and reduction simultaneously.
(iv) Example: $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$.

163. Why are metals considered reducing agents and non-metals considered oxidizing agents?

Ans :

(i) Metals readily lose electrons.
(ii) Therefore they reduce other substances and get oxidized themselves.
(iii) Non-metals readily gain electrons.
(iv) Therefore they oxidize other substances and get reduced themselves.

164. State and explain the three necessary conditions for combustion.

Ans :

(i) Presence of oxygen or supporter of combustion.
(ii) Presence of a combustible substance.
(iii) Attainment of ignition temperature.
(iv) Absence of any one condition stops combustion.

165. Differentiate between photochemical and electrochemical reactions with two examples each.

Ans :

Photochemical Reaction	**Electrochemical Reaction**
Requires light	Requires electricity
Example: Photosynthesis	Example: Electrolysis of water
Example: Decomposition of $AgNO_3$	Example: Electrolysis of molten NaCl
Energy source is light	Energy source is electricity

166. A student places four metals—magnesium, iron, copper and silver—in separate beakers containing dilute hydrochloric acid.
Predict the observations and justify your answer.

Ans :

(i) Magnesium reacts vigorously and liberates hydrogen.
(ii) Iron reacts slowly and liberates hydrogen.
(iii) Copper shows no reaction.
(iv) Silver shows no reaction because copper and silver lie below hydrogen in the activity series.

167. Justify the following statements:
(i) Passing hydrogen to boiling sulphur lead to a chemical change.
(ii) Electrolysis is a chemical change.

Ans :

(i) When we pass H_2 through sulphur, a compound called hydrogen sulphide is formed.

$$H_2 + S \longrightarrow H_2S$$

As a new product is formed as a result of reaction, therefore, this can be regarded as a chemical change.
(ii) During electrolysis, water is converted into its constituents hydrogen and oxygen whose property is entirely different from water so, it is a chemical change.

168. Give balanced chemical equation for the action of heat on the following:

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(i) Red lead
(ii) Lead dioxide
(iii) Potassium dichromate
(iv) Silver oxide
(v) Mercuric oxide.

Ans :

(i) $2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$
(ii) $2PbO_2 \xrightarrow{\Delta} 2PbO + O_2$
(iii) $4K_2Cr_2O_7 \xrightarrow{\Delta} 4K_2CrO_4 + 2Cr_2O_3 + 3O_2$
(iv) $2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$
(v) $2HgO \xrightarrow{\Delta} 2Hg + O_2$

169. Give an example of each of the following chemical change:

(a) An exothermic and an endothermic reaction involving carbon as reactant.
(b) A photochemical reaction involving silver salt.
(c) A reaction involving the formation of precipitate.
(d) A reaction where colour change occurs.

Ans :

(a) Exothermic reaction:
$C(s) + O_2(g) \xrightarrow{\Delta} CO_2(g) + \text{Heat}$
Endothermic reaction:
$C(s) + H_2O(g) + \text{Heat} \xrightarrow{\Delta} CO(g) + H_2(g)$
(b) $2AgNO_3 \xrightarrow{\text{Sunlight}} 2Ag + 2NO_2 + O_2$
(c) $AgNO_3 + NaCl \longrightarrow \underset{\text{(White ppt.)}}{AgCl\downarrow} + NaNO_3$
(d) $Fe + \underset{\text{(Blue colour)}}{CuSO_4(aq)} \longrightarrow \underset{\text{(Green)}}{FeSO_4} + Cu$

CASE BASED QUEATIONS

170. Aarav performs a series of thermal experiments in his school laboratory. First, he strongly heats solid ammonium chloride in a test tube and carefully observes two colourless gases forming a white sublimate on the cooler upper sides. Later, he heats white lead nitrate crystals in a separate test tube and notices the distinct release of a reddish-brown gas.

(a) Write the balanced chemical equation for the action of heat on solid ammonium chloride.
(b) Name the reddish-brown gas evolved and the solid residue left behind when lead nitrate is heated.
(c) State two fundamental differences between the chemical processes of thermal dissociation and thermal decomposition.

Ans :

(a) The balanced chemical equation for the thermal dissociation of ammonium chloride is represented as $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$, where two colourless gases are formed.
(b) When lead nitrate crystals are heated, the reddish-brown gas evolved is nitrogen dioxide, and the solid yellow residue left behind in the test tube is lead monoxide.
(c) 1. Thermal dissociation occurs when a substance breaks up into simpler substances on heating, and these products readily recombine to give back the original substance on cooling, making it completely reversible.
2. Thermal decomposition is a permanent chemical reaction brought about by heat where a complex compound splits into simpler inorganic compounds or elements, and this process is strictly irreversible.

171. Kavya is studying different classical concepts of chemical reactions. She passes hydrogen sulphide gas through chlorine gas and observes the formation of hydrogen chloride along with solid sulphur. In a separate, subsequent experiment, she carefully passes hydrogen gas over heated copper(II) oxide, which results in the formation of solid copper and water.

(a) Define the chemical process of oxidation strictly in terms of hydrogen transfer.
(b) Identify the specific reducing agent acting in Kavya's second experiment involving copper(II) oxide.
(c) Write the fully balanced chemical equations, including state symbols, for both of the experiments performed by Kavya.

Ans :

(a) Oxidation is accurately defined as a chemical reaction that involves a distinct decrease in the proportion of hydrogen or the complete removal of hydrogen from a given chemical substance.
(b) The specific reducing agent in the second experiment is hydrogen gas, because it actively reduces the copper(II) oxide to solid copper while itself getting oxidised to form water.

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(c) 1. The balanced chemical equation for the first reaction involving hydrogen sulphide and chlorine is strictly written as $H_2S(g) + Cl_2(g) \rightarrow 2HCl(g) + S(s)$.
2. The balanced chemical equation for the second reaction involving copper oxide and hydrogen is cleanly written as $CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$.

172. Rohan places a few pieces of zinc into a glass beaker containing a bright blue aqueous solution of copper sulphate. He stirs the mixture thoroughly with a glass rod. Over a short period of time, he observes the blue colour of the solution gradually fading until it becomes completely colourless, while reddish-brown particles slowly settle at the bottom.

(a) Explain the chemical process occurring in the beaker and state the reason why the solution's colour changes.

(b) Define the specific chemical series governing this reaction, and write the balanced chemical equation with correct state symbols.

Ans :

(a) 1. The chemical process occurring is a single displacement reaction, where the more reactive active metal zinc successfully displaces the less active metal copper from its original salt solution.
2. The blue colour of the aqueous copper sulphate solution gradually fades and turns completely colourless because an entirely new compound, aqueous zinc sulphate, is formed during the reaction.

(b) 1. The activity series, also called the electrochemical series, practically determines the ability of an element to displace another less reactive element based on its specific relative position.
2. The completely balanced chemical equation for this specific displacement reaction is written exactly as $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$, showing the formation of the metallic deposit.

173. Meera is actively studying the electronic concept of chemical reactions in her chemistry textbook. During her revision, she observes the theoretical conversion of a neutral sodium atom into a positively charged sodium ion, alongside the conversion of a positively charged copper ion into a neutral, solid copper atom. She wishes to classify these specific atomic transformations.

(a) Define the terms oxidation and reduction explicitly based on the electronic concept studied by Meera.

(b) Write the exact half-equations for the formation of the sodium ion and the solid copper atom, clearly identifying the specific process for each.

Ans :

(a) 1. According to the foundational electronic concept in chemistry, oxidation is specifically defined as the complete loss of one or more electrons by a reacting species, such as an atom or ion.
2. Conversely, the chemical process of reduction is specifically defined as the direct gain of one or more electrons by a chemical species, such as an atom, a molecule, or an ion.

(b) 1. The formation of a sodium ion is an oxidation process, representing a clear loss of electrons, and its half-equation is clearly written as $Na \rightarrow Na^+ + e^-$.
2. The formation of a solid copper atom is a reduction process, representing a distinct gain of electrons, and its half-equation is cleanly written as $Cu^{2+} + 2e^- \rightarrow Cu$.

174. Aditya is assigned two distinct chemical tasks to demonstrate energy variations in reactions. First, he cautiously adds water to solid quicklime inside a beaker, immediately hearing a loud hissing sound while the beaker becomes extremely hot to the touch. Second, he heats a mixture of carbon and sulphur to an exceptionally high temperature to form liquid carbon disulphide, noting that this requires constant external heating.

(a) Name the alkaline substance produced when water is thoroughly added to the solid quicklime.

(b) Write the balanced chemical equation for the vigorous reaction occurring between quicklime and water.

(c) State the type of chemical reaction demonstrated by the high-temperature formation of carbon disulphide.

(d) Write the balanced chemical equation for the reaction occurring between carbon and sulphur.

Ans :

(a) When water is added to quicklime, a rigorous chemical reaction occurs, resulting in the production of an alkaline substance

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formally known as calcium hydroxide or slaked lime.

(b) The completely balanced chemical equation for this specific highly exothermic reaction is correctly written as $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + \text{Heat}$, which naturally produces a loud hissing sound.

(c) An endothermic reaction is a chemical change where external heat is absorbed, causing a decrease in temperature, meaning the total energy content of products heavily exceeds the initial reactants.

(d) The correctly balanced chemical equation for the strongly endothermic reaction taking place between carbon and sulphur is definitively written as $C(s) + 2S(s) \xrightarrow{\Delta} CS_2(i)$, forming liquid carbon disulphide.

175. Sneha is carefully organizing chemical reagents in the school laboratory. She notices that solutions of silver nitrate are kept strictly in dark brown glass bottles. Her teacher explicitly explains that certain chemicals undergo rapid decomposition when exposed to particular environmental conditions. To test this, Sneha safely exposes a small sample of white silver chloride to direct natural sunlight.

(a) Give a specific reason why silver nitrate solutions must be stored strictly in dark brown bottles.

(b) State the distinct visible colour change observed when the silver chloride is exposed to direct sunlight.

(c) Write the balanced chemical equation representing the complete decomposition of the exposed silver chloride.

(d) Name the specific industry or common application where these particular decomposition reactions of silver halides are practically used.

Ans :

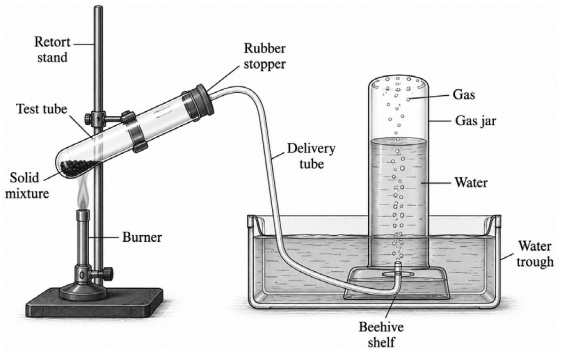
(a) Aqueous solutions of silver nitrate are kept in dark brown bottles because ambient light energy easily causes them to break down and undergo rapid photochemical decomposition in the laboratory.

(b) When white crystals of silver chloride are actively exposed to natural sunlight, a distinct visible colour change occurs as the compound slowly turns into fine particles of grey silver.

(c) The completely balanced chemical equation for the photochemical decomposition of silver chloride is correctly represented as $2AgCl(s) \xrightarrow{\text{Sunlight}} 2Ag(s) + Cl_2(g)$, releasing greenish-yellow chlorine gas into the air.

(d) These specific photochemical decomposition reactions heavily involving silver halides, such as silver chloride and silver bromide, are historically and practically used in traditional black and white photography applications.

176. Dev heats a chemical compound with and without a specific black powder to observe the rate of gas evolution. The diagram below illustrates the laboratory setup used for the rapid generation of this gas.



(a) Name the black powder added to the solid mixture and state its specific function in this process.

(b) Write the balanced chemical equation for the rapid reaction occurring inside the heated test tube.

(c) Define the term positive catalyst and give another example from the chapter where one is used.

Ans :

(a) The granular black powder added to the solid mixture is manganese dioxide, which functions specifically as a positive catalyst to dramatically accelerate the reaction's overall rate of decomposition.

(b) The completely balanced chemical equation for the catalytic decomposition of potassium chlorate is accurately written as $2KClO_3(s) \xrightarrow[300^\circ C]{MnO_2} 2KCl(s) + 3O_2(g)$, safely producing vital oxygen gas bubbles.

(c) 1. A positive catalyst is a specific chemical substance that actively accelerates the overall rate of a chemical reaction without getting permanently consumed or chemically altered itself at the end.

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2. Another clear example highlighted from the chapter is the use of finely divided iron acting as a vital positive catalyst during the high-pressure synthesis of ammonia in Haber's process.

177. Ananya pours one completely colourless aqueous solution into another completely colourless aqueous solution to study the specific conditions required for a chemical change. The diagram below shows the resulting mixture.

(a) Name the opaque yellow solid substance immediately forming in the central receiving test tube.

(b) Write the fully balanced chemical equation for this chemical reaction, including correct state symbols.

(c) State the specific condition for a chemical change that is demonstrated here, and name the reaction type.

Ans :

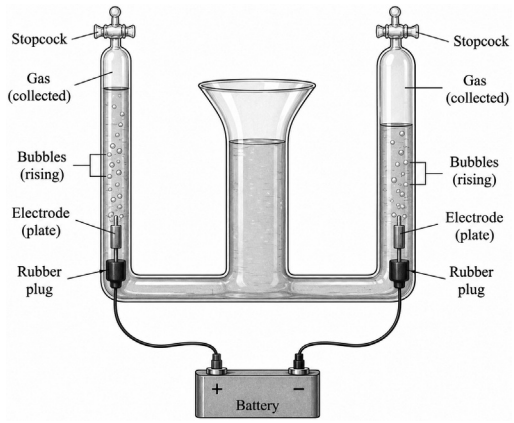
(a) The highly opaque, bright yellow solid substance immediately forming and settling in the central receiving test tube is a distinct insoluble precipitate formally named lead iodide.

(b) The completely balanced chemical equation for this rapid precipitation reaction is accurately written as $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow 2KNO_3(aq) + PbI_2(s)\downarrow$, showcasing the physical state changes.

(c) 1. The specific necessary condition practically demonstrated in this mixing experiment is close contact, where a chemical reaction successfully takes place when reacting substances get physically mixed in an aqueous state.

2. This highly interactive chemical process accurately represents a double decomposition precipitation reaction, because two individual compounds in their aqueous state react to cleanly produce an entirely new insoluble salt.

178. Varun meticulously investigates the breakdown of acidulated water by passing a steady electric current completely through it. The diagram below shows the specialized apparatus used for this experiment.



(a) Define electrolytic decomposition exactly as the concept is provided in the chemistry chapter.

(b) Write the balanced chemical equation for the reaction shown and state why the water must be acidulated.

Ans :

(a) 1. Electrolytic decomposition is precisely defined as a chemical process involving the permanent breakdown or decomposition of a specific complex substance by passing an electric current continuously through it.

2. The balanced chemical equation for the complete electrolytic decomposition of liquid water is properly written as $2H_2O(l) \xrightarrow{\text{Electricity}} 2H_2(g) + O_2(g)$, yielding pure hydrogen and oxygen gases at the electrodes.

(b) 1. The pure water must be properly acidulated before passing the electric current because adding a small amount of acid makes the pure water significantly more conducting for the electricity.

2. During this controlled electrolytic decomposition process, hydrogen gas is selectively collected entirely at the cathode, while oxygen gas is

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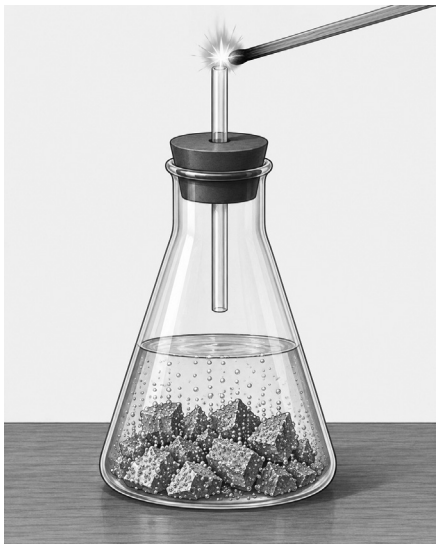
simultaneously collected entirely at the anode of the specialized apparatus.

179. Priya places some irregularly shaped metallic pieces into a flask and adds an acid to study the easily observable characteristics of chemical reactions. The diagram below illustrates her observations.



(a) Identify the specific gas evolving from the liquid and the chemical phenomenon of these gas bubbles escaping.

(b) Write the balanced chemical equation for the reaction, assuming the acid is dilute hydrochloric acid and the metal is zinc.

Ans :

(a) 1. The specific invisible gas actively evolving from the clear liquid inside the flask is hydrogen, which is experimentally confirmed by its characteristic burning with a small pop sound.

2. The highly visible phenomenon of these tiny gas bubbles rapidly escaping from an aqueous liquid solution during an ongoing chemical reaction is scientifically referred to as effervescence.

(b) 1. Assuming the solid metal is zinc and the clear acid is dilute hydrochloric acid, this chemical change is a perfect example of a single displacement reaction successfully taking place.

2. The fully balanced chemical equation for this specific chemical reaction is accurately written as $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$, clearly showing the continuous evolution of hydrogen gas.

180. Siddharth performs a simple experiment to observe a chemical change that yields multiple distinct products. The diagram below shows the action he performs using a common household material.

(a) Name the complex chemical substance that the paper sheet is primarily composed of.

(b) Write the complete chemical formula of the substance named in part (a).

(c) State the three distinct products formed when this rectangular sheet is entirely burnt in air.

(d) Identify the two forms of energy evolved during this specific chemical change.

Ans :

(a) Based entirely on the provided chapter's chemical details, the complex chemical substance that standard paper is primarily composed of is a material known as cellulose.

(b) The specific chemical formula representing cellulose, which undergoes rapid oxidation when the rectangular paper sheet is burnt in air, is correctly written as $(C_6H_{10}O_5)n$.

(c) When the delicate cellulose sheet is completely burnt in atmospheric air, the three distinct chemical products formed are carbon dioxide, water vapour, and a black-coloured ash.

(d) This specific chemical change is an exothermic reaction because it always involves the simultaneous evolution and outward physical release of both intense heat and visible light energy.

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181. Neha completely submerges a solid powder into a concentrated acid solution to demonstrate a specific type of chemical reaction. The diagram below captures the exact visual transformation of the liquid.

(a) Identify the black powder and the clear liquid based exclusively on the colour change described.

(b) Name the specific type of double decomposition reaction that this chemical experiment physically demonstrates.

(c) Write the fully balanced chemical equation, including state symbols, for this particular reaction.

(d) State the formal definition of the type of reaction named in part (b) as strictly given in the chapter.

Ans :

(a) Based exclusively on the resulting bright blue solution, the fine black powder added is copper oxide, and the clear colourless liquid is simply concentrated sulphuric acid.

(b) This specific chemical experiment elegantly demonstrates a double decomposition neutralisation reaction, taking place completely between an insoluble metallic base and a strong acid in the laboratory.

(c) The completely balanced chemical equation for this neutralisation interaction is accurately written as $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$, cleanly producing a soluble blue salt.

(d) A neutralisation reaction is accurately defined as the specific chemical reaction exclusively occurring between an acid and a base that strictly forms a salt and water only.

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NODIA

CHAPTER 3

Water

SUMMARY

1. WATER

Water is indispensable for the survival of life on the earth. Approximately, 80% of the earth's surface is covered by water. Water is the main part of all the living matter.

1.1 Occurrence of Water

Water exists in all the three states of matter. In all three states, water occurs in free form.

(i) Solid: Large amount of water is found in the form of ice or snow.

(ii) Liquid: In liquid state, most of the water is present in sea, rivers, lake, ocean, ponds, streams, spring, etc. Water also occurs under the surface of the earth called ground water.

(iii) Gas: Mist, fog are the examples of water in its gaseous form. It is also present as water vapours in the atmosphere.

In combined state, water is present in carbohydrates, proteins, etc. as well as in the salts in the form of water of crystallisation. It is the definite number of water molecules which enters into loose chemical combination when the salt crystallises out of its saturated solution.

For example,

1. $CuSO_4.5H_2O$ – Blue vitriol (Hydrated copper sulphate)
2. $FeSO_4.7H_2O$ – Green vitriol (Hydrated ferrous sulphate)

2. HYDRATED SALTS

The salts containing water of crystallisation are called hydrated salts.

2.1 Effect of Heat on Hydrated Salts

Hydrated salts on heating lose their water of crystallisation and become anhydrous.

Hydrated salts on heating lose their crystalline shape and colour. For example, hydrated copper sulphate on heating changes from blue to white and its crystalline shape changes to amorphous.

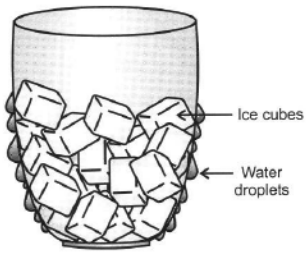
$$\underset{\text{Blue}}{CuSO_4.5H_2O} \xrightarrow{\Delta} \underset{\text{White}}{CuSO_4} + 5H_2O$$

On heating a hydrated salt, water of crystallisation are given out in the form of steam and they condense on the upper cooler portion of the test-tube.

If water is added to an anhydrous compound, the anhydrous compound regains its original colour. For example, if water is allowed to drop over the white anhydrous copper sulphate, then it changes to blue.

2.2 To Show the Presence of Water in Atmosphere

When a glass filled with ice is kept in atmosphere, water droplets condense on the outer cooler surface of glass. This experiment shows that water is present in our atmosphere.



2.3 To Show that Tap Water Contains dissolved Salts

In a beaker of capacity 100 mL add 50 mL of water. Over the beaker, place the watch glass containing tap water and set the experiment as shown in the figure. Heat the contents of the beaker. Water starts boiling and the steam produced evaporates the water in the watch glass slowly. Continue heating till all the water in the watch glass completely evaporates. When the watch glass is removed from the beaker, the

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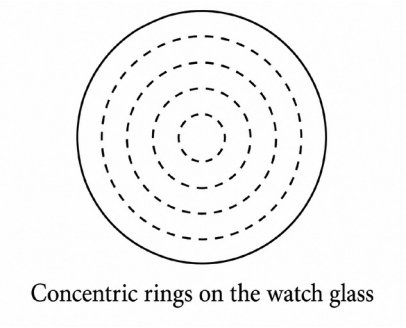
concentric rings of solid material are seen on the watch glass. The rings are of salts which are present in dissolved form in water.



Concentric rings on the watch glass

3. FORMATION OF WATER

Water is a compound of hydrogen and oxygen. It can be produced

(i) By burning of hydrogen in air: Pure hydrogen burns in pure oxygen with pale blue flame to form the droplets of colourless liquid (water).

$$2H_2 + O_2 \longrightarrow 2H_2O$$

(ii) By burning of hydrocarbons in air: Hydrocarbons burn in free supply of air or oxygen to form carbon dioxide and water vapour.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$$

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

(iii) By the reduction of metallic oxides by hydrogen: During these reactions, hydrogen gets oxidized to form water.

$$CuO + H_2 \longrightarrow Cu + H_2O$$

$$PbO + H_2 \longrightarrow Pb + H_2O$$

(iv) During the process of respiration: Carbohydrates burn in the presence of oxygen to form carbon dioxide and water vapour with the liberation of energy.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Heat}$$

3.1 Effect of Temperature and Pressure on Solubility of Gases:

The solubility of gases in a liquid decreases with rise in temperature and vice versa.

On increasing the pressure on the surface of liquid at any temperature, the solubility of gas increases which is in accordance with Henry's law. It states, "At any given temperature, the mass of the gas dissolved in fixed volume of liquid is directly proportional to the pressure of the surface of the liquid".

4. CHEMICAL PROPERTIES OF WATER

The chemical properties of water are:

(i) Action towards litmus: Pure water is neutral towards litmus, i.e. it neither turns red litmus to blue nor blue litmus to red.

(ii) Stability: Water is a stable compound. It does not break into its elements when heated in ordinary conditions. However, if electric current is passed through acidified water, it decomposes to give hydrogen at cathode and oxygen at anode in the ratio of 2 : 1 respectively by volume.

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$HCl \rightleftharpoons H^+ + Cl^-$$

$$\text{At Cathode} \quad H^+ + e^- \longrightarrow [H]$$

$$2[H] \longrightarrow H_2$$

$$\text{At Anode} \quad OH^- - e^- \longrightarrow OH$$

$$4[OH] \longrightarrow 2H_2O + O_2$$

(iii) In many chemical reactions, water acts as a catalyst like

$$H_2 + Cl_2 \xrightarrow[\text{moisture}]{\text{Sunlight}} 2HCl$$

$$4P + 5O_2 \xrightarrow[\text{moisture}]{\Delta} 2P_2O_5$$

(iv) Reaction with metals:

(a) Reaction of cold water with sodium and potassium: When sodium or potassium is dropped into a trough of cold water it reacts explosively and forms its respective hydroxide with the liberation of hydrogen gas.

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2$$

$$2K + 2H_2O \longrightarrow 2KOH + H_2$$

When both of these metals are placed in water, they melt and form a silvery ball. As these metals are lighter than water, therefore, they float on the surface of water and starts moving in a zig-zag manner. Tiny bubbles of hydrogen gas are evolved and the metals catch fire. If it is sodium, then it burns with golden yellow flame and if it is potassium it burns with violet or lilac colouration. The solution left behind after the reaction is soapy to touch and turns

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red litmus to blue showing that it is alkaline in nature.

(b) Reaction with magnesium, zinc and aluminium:

$$Mg + \underset{\text{steam}}{H_2O} \longrightarrow MgO + H_2$$

$$Zn + \underset{\text{steam}}{H_2O} \longrightarrow ZnO + H_2$$

$$2Al + \underset{\text{steam}}{3H_2O} \longrightarrow Al_2O_3 + 3H_2$$

(c) Reaction with iron:

$$\underset{\text{heated}}{3Fe} + \underset{\text{steam}}{4H_2O} \rightleftharpoons Fe_3O_4 + 4H_2$$

(d) Metals present below hydrogen in the metal activity series do not displace hydrogen from water, e.g. copper, silver, gold, etc. Mercury does not react with water even under drastic conditions.

(v) Reaction with soluble basic oxides: Soluble basic oxides dissolve in water to give respective soluble bases called alkalies which turn red litmus blue.

$$Na_2O + H_2O \longrightarrow 2NaOH$$

$$K_2O + H_2O \longrightarrow 2KOH$$

$$CaO + H_2O \longrightarrow \underset{\text{sparingly soluble in water}}{Ca(OH)_2}$$

(vi) Reaction with acidic oxides: Acidic oxides are also called acid anhydrides. On dissolving in water they produce acids which turn blue litmus red.

$$CO_2 + H_2O \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$$

$$SO_2 + H_2O \longrightarrow \underset{\text{Sulphurous acid}}{H_2SO_3}$$

$$SO_3 + H_2O \longrightarrow \underset{\text{Sulphuric acid}}{H_2SO_4}$$

$$P_2O_5 + 3H_2O \longrightarrow \underset{\text{Phosphoric acid}}{2H_3PO_4}$$

$$\underset{\substack{\text{Mixed}\\\text{anhydride}}}{2NO_2} + H_2O \longrightarrow \underset{\text{Nitrous acid}}{HNO_2} + \underset{\text{Nitric acid}}{HNO_3}$$

(vii) Reaction with non-metals:

(a) Reaction with carbon: When superheated steam is passed over white hot coke, an endothermic reaction takes place with the formation of equi-volume mixture of carbon monoxide and hydrogen called water gas.

$$\underset{\text{White hot coke}}{C} + \underset{\text{Superheated steam}}{H_2O} \longrightarrow \underbrace{CO + H_2}_{\text{Water gas}}$$

(b) Reaction with chlorine: When chlorine is passed through water in dark, it forms a greenish yellow solution called chlorine water. When chlorine water is exposed to sunlight, the following changes occur:

(i) Greenish yellow chlorine water decolourises.

(ii) A colourless and odourless gas evolves which relights the glowing splinter.

$$\underset{\text{Chlorine}}{Cl_2} + \underset{\text{Water}}{H_2O} \xrightarrow{\text{dark}} \underbrace{Cl_2 + H_2O}_{\substack{\text{Chlorine water}\\\text{(Greenish yellow}\\\text{solution)}}}$$

$$\underbrace{Cl_2 + H_2O}_{\substack{\text{Chlorine water}\\\text{(Greenish yellow}\\\text{solution}}} \xrightarrow[\text{sunlight}]{\text{diffused}} \underbrace{HCl}_{\substack{\text{Hydrochloric}\\\text{acid}}} + \underbrace{HOCl}_{\substack{\text{Hypochlorous}\\\text{acid}}}$$

$$HOCl \xrightarrow{h\nu} HCl + [O]$$

$$2[O] \longrightarrow O_2$$

$$2Cl_2 + 2H_2O \xrightarrow[\text{sunlight}]{\text{direct}} 4HCl + O_2$$

5. TEST TO SHOW THE COLOUR OF WATER:

Water is a colourless liquid which can be tested as follows:

(i) It turns anhydrous copper sulphate from white to blue.

$$\underset{\text{White}}{CuSO_4} + 5H_2O \longrightarrow \underset{\text{Blue}}{CuSO_4.5H_2O}$$

(ii) It turns anhydrous cobalt chloride from blue to pink.

$$\underset{\text{Blue}}{CoCl_2} + 6H_2O \longrightarrow \underset{\text{Pink}}{CoCl_2.6H_2O}$$

6. SOLUTION

A solution is a homogeneous mixture of solute and solvent. Homogeneous mixture has uniform composition and properties in its every part.

6.1 Dissolution

During the formation of the solution, the solute and solvent do not undergo any chemical reaction. Only a physical change takes place and the process of the disappearance of solute in a solvent is called dissolution.

6.2 The Solution and its Properties:

Dissolution of sugar (solute) in water (solvent) leads to the formation of true solution. Its properties are:

(i) A true solution is homogeneous in nature.

(ii) The, particles of true solution can easily pass through the filter paper.

(iii) The particles of true solution does not settle down under the influence of gravity.

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(iv) The components of true solution (i.e. solute and solvent) can be easily separated by simple physical means (evaporation, distillation, etc.).
(v) The particles of true solution cannot be seen with the help of microscope.

6.3 Solvent

The component which allows a substance to dissolve in it is called solvent.

6.4 Solute

The component which dissolves in a substance (solvent) is called solute.

7. TYPES OF SOLUTION

In a solution, the quantity of solute and solvent can be changed and on the basis of this the solutions are divided in two categories.
(i) Dilute solution: If the proportion of solute is relatively very small as compared to the quantity of the solvent, then the solution is called dilute solution.
(ii) Concentrated solution: If the proportion of solute is relatively large as compared to the quantity of solvent, then it is called concentrated solution.

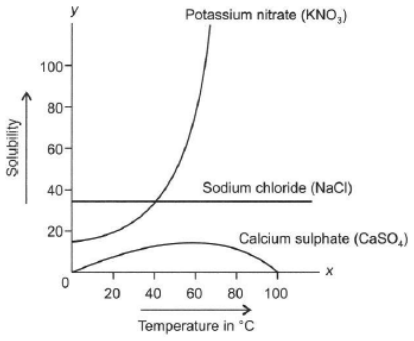
7.1 Types of Solution on the Basis of Solubility:

Solution can also be classified on the basis of their solubility, i.e. depending upon the amount of solute that dissolves in a given solvent.
(i) Unsaturated solution: If more solute can be dissolved in a solvent at a particular temperature, then the solution is called unsaturated solution.
(ii) Saturated solution: If no more solute can be dissolved in a solvent at a particular temperature, then the solution is called saturated solution.
(iii) Supersaturated solution: If the solution contains more of the solute, than the saturated solution at some higher temperature is called supersaturated solution.

8. SOLUBILITY CURVE:

A graph between solubility of a solid and temperature is called solubility curve. The uses of solubility curves are:
(i) Solubilities of different substances at a particular temperature can be recorded and compared.
(ii) To find the solubility of a given substance at a particular temperature.

The solubility curves of calcium sulphate, potassium nitrate and sodium chloride are given below in graph. The curves indicates



(i) Calcium sulphate: There is a decrease in solubility (after a certain temperature) with further rise in temperature.
(ii) Sodium chloride: There is a negligible increase in the solubility of sodium chloride with rise in temperature.
(iii) Potassium nitrate: Solubility increases with the rise in temperature.

8.1 Drying agents

Substances which remove moisture from other substances are called drying agents. For example, quick lime, phosphorus pentoxide.

8.2 Dehydrating agents

These are the substances which can remove water molecules even from compounds. For example, concentrated H_2SO_4.

8.3 Efflorescence:

Hydrated salts when left exposed to atmosphere lose their water of crystallisation and crumble down to form powder such salts are called efflorescent salts and the property as efflorescence, e.g. Washing soda $Na_2CO_3.10H_2O$and Glauber's salt $Na_2SO_4.10H_2O$.

8.4 Deliquescence:

Certain salts when left exposed to atmosphere absorb moisture and get converted into their saturated solution. Such salts are called deliquescent salts and the property as deliquescence, e.g. ferric chloride and magnesium chloride.

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8.5 Hygroscopy

Certain substances when left exposed to atmosphere absorb moisture from the air and become wet. Such substances are called hygroscopic substances and the property is known as hygroscopy. Hygroscopic substances are also called drying agents, e.g. phosphorus pentaoxide, conc. sulphuric acid, anhydrous calcium chloride.

9. CRYSTAL

The solids bounded by the plane surfaces directed at definite angles and having definite geometrical shapes are called crystals.

10. AMORPHOUS SOLIDS:

The solids which are not essentially homogeneous and are not bounded by the plane surfaces at definite angles to one another and do not have definite geometrical shapes are called amorphous solids.

11. CRYSTALLISATION

The process of separating out the crystals from the hot saturated solution on cooling it slowly is called crystallisation.
For the formation of crystals, the hot saturated solution must be cooled slowly. If rapid cooling is done then the amorphous solid settles at the base instead of crystals.

12. WATER POLLUTION

Presence of any undesirable substances in the water bodies, such as lake, river and ocean is called water pollution.
The major causes of water pollution are: Household waste, Sewage, Detergents, Industrial waste, Offshore and oil drilling.
The major water pollutants are: Microorganisms in domestic sewage, Decaying animals and plants, Discharge of untreated waste into the water bodies from the factories, Insecticides, Pesticides, Oil slicks, Fungicides, Heat, etc.

12.1 Soft water

The water which has low concentration of dissolved minerals in it and gives lather easily with soap is called soft water, e.g. rainwater and distilled water.

Advantage of soft water:
It gives lather easily with soap. Besides, it does not stain clothes by forming sticky scum, therefore, cleaning of clothes becomes easy.

Disadvantages of soft water:

Soft water is not good for healthy teeth and bones as it does not contain salts. Soft water has a unpleasant taste in mouth.

12.2 Hard water:

The water which has appreciable quantity of dissolved minerals (like calcium and magnesium) and does not give lather with soap is called hard water, e.g. natural water, such as well water and spring water.

Advantage of hard water:

Hard water is good for healthy teeth and bones as it contains dissolved salts of calcium and iron in it. Besides, it gives a pleasant taste to the water due to the presence of dissolved minerals in it.

Disadvantage of hard water:

Hard water does not lather with soap and forms a sticky scum which stains the fabrics.

12.3 Cause of hardness of water:

The hardness of water is due to the presence of bicarbonates, chlorides and sulphates of Calcium and Magnesium.

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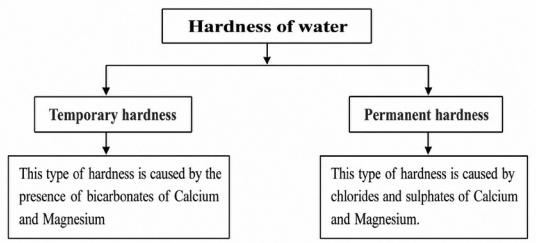
13. TYPE OF HARDNESS:

The hardness of water is of two types.


Hardness of water
Temporary hardness
Permanent hardness
This type of hardness is caused by the presence of bicarbonates of Calcium and Magnesium
This type of hardness is caused by chlorides and sulphates of Calcium and Magnesium.

OBJECTIVE QUESTIONS

1. What is the precise fixed ratio by mass of hydrogen and oxygen combined in a single molecule of pure water?

(A) 21
(B) 18
(C) 81
(D) 116

Ans : (B)

Pure water is a stable chemical compound composed entirely of hydrogen and oxygen elements. According to the fundamental law of definite proportions, these constituent elements are always combined in a fixed chemical ratio of exactly one to eight by mass, regardless of the physical water source.

2. An experiment is conducted to compare the heating characteristics of water and ethanol. Equal masses of both liquids are heated using identical sources of heat.

Liquid	**Specific Heat Capacity ($J\ g^{-1}\ °C^{-1}$)**	**Temperature Rise in 5 minutes (°C)**
Water	4.2	10
Ethanol	2.4	17.5

Which statement correctly interprets the observations in the table?
(A) Water heats up faster due to its lower specific heat capacity.
(B) Ethanol's higher specific heat capacity allows it to absorb more heat.
(C) Water's high specific heat capacity causes it to resist a rapid temperature change.
(D) Both liquids have the same rate of temperature change per joule of energy.

Ans : (C)

Water has a significantly higher specific heat capacity (4.2 $J\ g^{-1}\ °C^{-1}$) than ethanol. This means it requires more heat energy to raise its temperature by one degree. The data confirms this, showing a smaller temperature rise for water over the same period, indicating it heats up slower and resists temperature change.

3. Consider the following statements regarding the characteristics of a true solution.
I. The solute particles have a size of roughly 10-10 m.
II. The solution easily scatters a beam of light passing through it.
III. It is possible to separate its components by simple laboratory filtration.
IV. The solute particles of a solution absolutely do not settle down.

Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and IV
(D) III and IV

Ans : (C)

A true aqueous solution is a perfectly homogeneous mixture where solute particles are microscopic, generally measuring about ten to the power of negative ten metres or less. These extremely tiny particles are much too small to scatter light, will never settle down, and cannot be separated by simple mechanical filtration.

4. Water is uniquely capable of dissolving a remarkably wide range of inorganic compounds. Which fundamental property is primarily responsible for lessening the electrostatic forces of attraction between positive and negative ions?
(A) High specific heat capacity
(B) Anomalous volume expansion
(C) High dielectric constant
(D) High latent heat of vapourisation

Ans : (C)

Liquid water is universally recognized as an exceptionally effective solvent primarily because it inherently possesses a remarkably high dielectric constant. This unique physical property enables water to significantly weaken the rigid electrostatic forces of attraction between positive and negative ions, easily facilitating the dissolution of numerous solid inorganic compounds.

5. How does a substantial decrease in atmospheric pressure, such as the conditions experienced at the top of Mount Everest, affect the physical boiling point of pure water?
(A) The boiling point remarkably increases to 120°C.
(B) The boiling point drops significantly to 70°C.
(C) The boiling point remains completely unaffected at 100°C.
(D) The boiling point drops slightly to 95°C.

Ans : (B)

The physical boiling point of liquid water is directly dependent upon the surrounding atmospheric pressure. At very high geographical altitudes, such as on the peak of Mount Everest, the ambient atmospheric pressure is significantly diminished, which consequently forces pure water to boil at merely seventy degrees Celsius.

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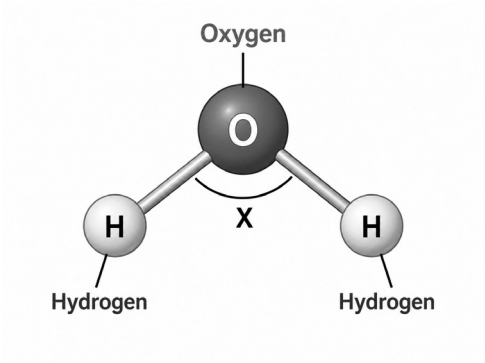
6. The diagram illustrates the bonding within a water molecule. What is the approximate angle at the point marked 'X' and what type of bond connects the atoms?



(A) 180°, Ionic bond
(B) 104.5°, Covalent bond
(C) 90°, Hydrogen bond
(D) 109.5°, Metallic bond

Ans :(B)

A water molecule has a bent or V-shaped structure due to the presence of two lone pairs on the oxygen atom. The atoms are joined by polar covalent bonds, where electrons are shared. The H-O-H bond angle, represented by 'X', is approximately 104.5°, a slight compression from the ideal tetrahedral angle.

7. Read the **Assertion (A) :** and Reason (R) carefully and select the correct option.
Assertion (A) : Solid ice easily floats on the top surface of a liquid water pond during extreme winter conditions.
Reason (R) : Water has a maximum density exactly at 4°C and subsequently expands in volume upon freezing into ice.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Liquid water exhibits a highly anomalous physical property where its maximum density reliably occurs at exactly four degrees Celsius. When it cools further and eventually freezes into solid ice, it expands significantly in volume. Consequently, the relative density of ice becomes noticeably less than liquid water, allowing it to float.

8. A student investigates the reaction of various non-metallic oxides with water and the nature of the resulting solution.

Non-metallic Oxide	**Formula of Product with Water**	**Nature of Product**
Carbon dioxide (CO_2)	H_2CO_3	Acidic
Sulphur dioxide (SO_2)	H_2SO_3	Acidic
Sulphur trioxide (SO_3)	H_2SO_4	Acidic
Nitrogen dioxide (NO_2)	X	Acidic

What is substance X, formed when nitrogen dioxide reacts with water?
(A) Only Nitric acid (HNO_3)
(B) A mixture of Nitrous acid (HNO_2) and Nitric acid (HNO_3)
(C) Only Nitrogen gas (N_2)
(D) A mixture of Nitrous oxide (N_2O) and Nitric acid (HNO_3)

Ans :(B)

Non-metallic oxides are generally acidic anhydrides, forming acids upon reaction with water. While most form a single corresponding acid, nitrogen dioxide is a mixed anhydride. It reacts with water to produce a mixture of two acids: nitrous acid (HNO_2) and nitric acid (HNO_3). Therefore, X represents this mixture.

9. Match the common names of the hydrated salts in List-I with their correct chemical formulas in List-II.
List-I (Common Name)
P. Blue vitriol
Q. Epsom salt
R. Washing soda
S. Glauber's salt
List-II (Chemical Formula)
I. $MgSO_4 \cdot 7H_2O$
II. $CuSO_4 \cdot 5H_2O$
III. $Na_2SO_4 \cdot 10H_2O$
IV. $Na_2CO_3 \cdot 10H_2O$
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-II, Q-IV, R-I, S-III
(D) P-III, Q-I, R-IV, S-II

Ans : (A)

Specific hydrated salts always contain a precisely

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fixed number of chemically bound water molecules. Blue vitriol represents copper sulphate pentahydrate. Epsom salt is widely known as magnesium sulphate heptahydrate. Washing soda naturally consists of sodium carbonate decahydrate. Finally, Glauber's salt is formally identified as sodium sulphate decahydrate.

10. A student prepares four different aqueous solutions of sodium chloride (NaCl) at the same temperature.

Solution	**Mass of NaCl (solute)**	**Mass of Water (solvent)**
P	20 g	100 g
Q	30 g	150 g
R	25 g	50 g
S	10 g	40 g

Which solution is the most concentrated?
(A) Solution P
(B) Solution Q
(C) Solution R
(D) Solution S

Ans : (C)

Concentration (mass %)
= [Mass of solute/(Mass of solute + Mass of solvent)] × 100.

P: $(20/120)\times100 = 16.7\%$.

Q: $(30/180)\times100 = 16.7\%$.

R: $(25/75)\times100 = 33.3\%$.

S: $(10/50)\times100 = 20\%$.

Solution R has the highest mass percentage of solute, making it the most concentrated solution among the four.

11. Strongly electropositive metals react vigorously with pure water. Which of the following specific metals does NOT react with cold water and requires either boiling water or hot steam to chemically displace hydrogen?
(A) Potassium
(B) Sodium
(C) Calcium
(D) Magnesium

Ans : (D)

Strongly electropositive metallic elements like pure potassium, sodium, and calcium chemically decompose cold water to violently liberate flammable hydrogen gas. However, elemental magnesium is comparatively far less reactive and absolutely does not react with cold water; it strictly requires boiling liquid water or hot steam to successfully form its corresponding oxide.

12. Who historically synthesized pure water in the year 1781 by actively igniting two complete volumes of flammable hydrogen gas with exactly one volume of pure oxygen gas using electric sparks?
(A) Antoine Lavoisier
(B) Henry Cavendish
(C) John Dalton
(D) Dmitri Mendeleev

Ans : (B)

Pure liquid water was incorrectly considered a fundamental basic element until the scientist Henry Cavendish historically synthesized it in 1781. He achieved this remarkable feat by successfully igniting exactly two volumes of pure hydrogen and one volume of pure oxygen, definitively proving its complex chemical compound nature.

13. **Assertion (A) :** The presence of a massive amount of ocean water can significantly modify the surrounding climate of nearby land areas, making them comfortably warmer in winter and distinctly cooler in summer.
Reason (R) : Pure water possesses a notably low specific heat capacity and consequently heats up exceptionally rapidly when directly exposed to intense sunlight.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Pure water actually possesses a remarkably high specific heat capacity, fundamentally meaning it effectively absorbs and subsequently releases massive quantities of thermal energy without undergoing rapid temperature fluctuations. This unique thermal property successfully allows massive water bodies to heavily regulate surrounding local climates, securely resisting rapid heating and extreme cooling.

14. The biological sustainability of aquatic marine life heavily depends on dissolved atmospheric gases. What is the approximate percentage composition of pure oxygen dissolved naturally in ordinary tap water compared to atmospheric air?
(A) 21% dissolved oxygen

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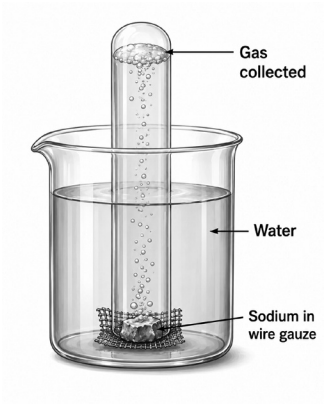
(B) 33% dissolved oxygen
(C) 66% dissolved oxygen
(D) 1% dissolved oxygen

Ans : (B)

In normal atmospheric air, the pure oxygen gas content remains approximately twenty-one percent. However, because highly reactive oxygen gas dissolves considerably more readily in liquid water than mostly inert nitrogen gas does, the final composition of natural air dissolved in water features a significantly higher oxygen proportion, reaching roughly thirty-three percent.

15. The experimental setup shows the reaction of a substance with cold water. Which observation correctly identifies the products of this reaction?



(A) A colourless, odourless gas is collected which extinguishes a glowing splint.
(B) A greenish-yellow gas is collected which turns moist starch iodide paper blue-black.
(C) A colourless, odourless gas is collected which burns with a 'pop' sound.
(D) A reddish-brown gas with a pungent smell is collected.

Ans : (C)

The diagram shows the reaction of sodium, an active metal, with cold water. This reaction produces sodium hydroxide and liberates hydrogen gas. Hydrogen is a colourless and odourless gas that is highly combustible and produces a characteristic 'pop' sound when a burning splint is brought near it, confirming its identity.

16. What are the exact chemical products smoothly formed when hot steam is continuously passed over strongly heated pure iron metal?
(A) Iron (II) oxide and pure water
(B) Iron (III) oxide and pure oxygen
(C) Triferric tetroxide and pure hydrogen
(D) Iron hydroxide and pure hydrogen

Ans : (C)

When hot steam is actively passed over strongly heated pure elemental iron, a highly distinct reversible chemical reaction smoothly occurs. The hot solid iron reacts directly with the hot gaseous steam to successfully produce magnetic triferric tetroxide, simultaneously liberating highly combustible pure hydrogen gas as a valuable secondary product.

17. The solubility of four different salts is determined at 40°C. The table shows the maximum mass of each salt that dissolves in 100 g of water.

Substance	**Solubility at 40°C (g/100 g of water)**
Sodium Chloride	36.5
Potassium Nitrate	63.0
Copper Sulphate	28.0
Sodium Nitrate	105.0

If 30 g of each substance is added to separate beakers each containing 100 g of water at 40°C, in which beaker will an unsaturated solution be formed?
(A) All four beakers will contain unsaturated solutions.
(B) Only the Copper Sulphate beaker will contain a saturated solution.
(C) Only the Potassium Nitrate and Sodium Nitrate beakers will contain unsaturated solutions.
(D) The Sodium Chloride beaker will contain a supersaturated solution.

Ans : (A)

(A) unsaturated solution is one that can still dissolve more solute. A solution is unsaturated if the mass of added solute is less than its solubility. In this case, 30 g of solute is added to each beaker. Since the solubility of all four substances at 40°C is greater than 30 g, all the added salt will dissolve, forming four unsaturated solutions.

18. What specific gaseous mixture is directly obtained when superheated steam is continuously passed over red-hot coke?
(A) Carbon dioxide and pure hydrogen
(B) Carbon monoxide and pure oxygen
(C) Carbon monoxide and pure hydrogen

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(D) Carbon dioxide and pure nitrogen

Ans : (C)

When superheated hot steam is aggressively passed over strongly red-hot coke, which serves as a highly reactive solid form of carbon, a specific endothermic chemical reaction reliably yields a combustible gaseous mixture primarily composed of carbon monoxide and pure hydrogen. This resulting combustible mixture is widely recognized as water gas.

19. The solubility of Potassium Nitrate and Calcium Sulphate in water is measured at different temperatures.

Temperature (°C)	**Solubility of KNO_3 (g/100g H_2O)**	**Solubility of $CaSO_4$ (g/100g H_2O)**
20	32	0.21
40	63	0.20
60	108	0.19

What conclusion can be drawn from the data?

(A) The solubility of all salts increases with an increase in temperature.

(B) Increasing temperature causes a large increase in the solubility of both KNO_3 and $CaSO_4$.

(C) The solubility of KNO_3 increases significantly, while $CaSO_4$ solubility slightly decreases with temperature.

(D) Calcium sulphate is more soluble than potassium nitrate at all listed temperatures.

Ans : (C)

The table shows that as the temperature rises from 20°C to 60°C, the solubility of potassium nitrate (KNO_3) increases dramatically from 32 g to 108 g. In contrast, the solubility of hydrated calcium sulphate ($CaSO_4$) shows a slight decrease over the same temperature range. This demonstrates different solubility-temperature behaviors.

20. Consider the following statements regarding the fundamental chemical properties of pure water.

I. Pure water is completely neutral to standard litmus paper.

II. Pure water easily decomposes rapidly into hydrogen and oxygen at roughly 500°C.

III. Pure water acts as a necessary catalyst in the explosive reaction between pure hydrogen and chlorine.

IV. All metallic oxides aggressively dissolve in pure water to uniquely form corresponding strong acids.

Which of the statements given above are correct?

(A) I and III

(B) II and IV

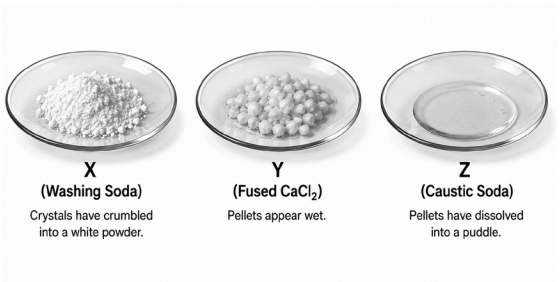
(C) I, II, and III

(D) III and IV

Ans : (A)

Pure liquid water is perfectly chemically neutral and absolutely does not visibly affect standard litmus paper. It acts as a necessary catalyst for the highly explosive chemical combination of hydrogen and chlorine. However, it remains highly thermally stable up to two thousand degrees, and active metallic oxides specifically form alkalis.

21. The diagram shows three different crystalline substances (X, Y, Z) left exposed to the atmosphere. Which row correctly identifies the phenomena occurring in each watch glass?



(A) X: Deliquescence, Y: Hygroscopy, Z: Efflorescence

(B) X: Efflorescence, Y: Deliquescence, Z: Hygroscopy

(C) X: Efflorescence, Y: Hygroscopy, Z: Deliquescence

(D) X: Hygroscopy, Y: Efflorescence, Z: Deliquescence

Ans : (C)

Efflorescence (X) is the loss of water of crystallisation to the air, causing the crystal to crumble. Hygroscopy (Y) is the absorption of atmospheric moisture without dissolving. Deliquescence (Z) is the process where a substance absorbs so much moisture from the air that it dissolves in the absorbed water.

22. Different highly reactive metal nitrides and carbides react with pure boiling water to liberate very specific distinct gases. Which of the following reaction pairs is completely strictly incorrect?

(A) Aluminium carbide reacts with water to yield pure methane gas.

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(B) Calcium carbide reacts with water to yield pure acetylene gas.
(C) Magnesium nitride reacts with water to yield pure ammonia gas.
(D) Calcium nitride reacts with water to yield pure nitrogen gas.

Ans : (D)

Highly reactive solid metal nitrides, such as heavy calcium nitride, active magnesium nitride, and solid aluminium nitride, react incredibly vigorously with hot boiling water. In these specific chemical reactions, they successfully form their corresponding metallic metal hydroxides and consistently release pure ammonia gas. They absolutely do not produce pure nitrogen gas.

23. Which specific visible chemical test is standardly used in laboratories to definitively confirm the actual presence of ordinary liquid water?
(A) White anhydrous copper sulphate turns bright blue
(B) Pink hydrated cobalt chloride turns bright blue
(C) Blue hydrated copper sulphate turns pure white
(D) White anhydrous cobalt chloride turns bright pink

Ans : (A)

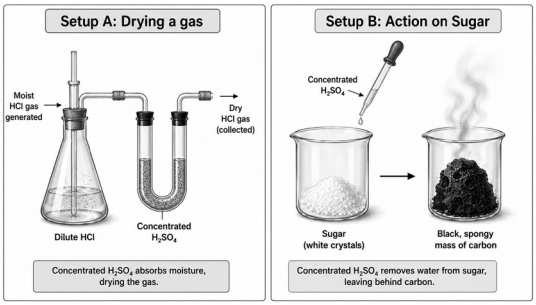
A highly standard visible chemical test for easily detecting the absolute physical presence of liquid moisture carefully involves treating white anhydrous copper sulphate powder. Upon direct physical contact with liquid water, it rapidly undergoes chemical hydration to visibly form hydrated copper sulphate, which definitively changes the testing substance completely blue.

24. Carefully arrange the following naturally occurring metallic elements in the strictly correct decreasing order of their chemical reactivity specifically towards liquid water.
(A) Potassium, Magnesium, Iron, Sodium
(B) Potassium, Sodium, Magnesium, Iron
(C) Sodium, Iron, Potassium, Magnesium
(D) Magnesium, Potassium, Sodium, Iron

Ans : (B)

Based solidly on the standard metal activity series, different metals react vastly differently with pure water. Highly reactive potassium and sodium react incredibly violently with cold water. Less reactive magnesium strictly requires boiling hot water to react, while moderately reactive iron only reacts with superheated steam under highly forced conditions.

25. The diagram contrasts two different actions of concentrated H_2SO_4. Which statement correctly describes the role of the acid in Setup B?


Setup A: Drying a gas
Moist HCl gas generated
Dry HCl gas (collected)
Dilute HCl
Concentrated H_2SO_4
Concentrated H_2SO_4 absorbs moisture, drying the gas.
Setup B: Action on Sugar
Concentrated H_2SO_4
Sugar (white crystals)
Black, spongy mass of carbon
Concentrated H_2SO_4 removes water from sugar, leaving behind carbon.

(A) It acts as a drying agent by absorbing moisture from the air.
(B) It acts as a dehydrating agent by chemically removing water elements.
(C) It acts as an oxidising agent by adding oxygen to the sugar.
(D) It acts as a catalyst to speed up the dissolution of sugar.

Ans : (B)

In Setup B, concentrated sulphuric acid is acting as a powerful dehydrating agent. It chemically removes hydrogen and oxygen atoms from the sugar molecule ($C_{12}H_{22}O_{11}$) in the 2:1 ratio of water, leaving behind a black mass of carbon. This is a chemical change, distinct from its physical action as a drying agent.

26. **Assertion (A) :** Adding completely soluble common salt to pure liquid water reliably elevates its standard boiling point significantly above 100°C.
Reason (R) : The physical presence of heavily dissolved chemical impurities naturally predictably increases the absolute physical boiling point of any given water sample.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The standard absolute boiling point of entirely pure liquid water under normal constant atmospheric pressure remains exactly one hundred degrees Celsius. However, the intentional deliberate addition of heavily dissolved chemical impurities, exactly like basic common salt, intimately predictably alters its basic physical constants, specifically easily causing an observable positive boiling elevation.

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27. The table shows properties of some common hydrated salts. Some data points are represented by X, Y and Z.

Common Name	Chemical Name	Formula	Colour
Blue Vitriol	Copper (II) sulphate pentahydrate	$CuSO_4 \cdot 5H_2O$	Blue
Green Vitriol	Iron (II) sulphate heptahydrate	X	Bluish green
Epsom Salt	Magnesium sulphate heptahydrate	$MgSO_4 \cdot 7H_2O$	Y
Washing Soda	Z	$Na_2CO_3 \cdot 10H_2O$	White

Identify the correct entities for X, Y, and Z.

(A) X = $FeSO_4 \cdot 5H_2O$, Y = Green, Z = Sodium sulphite

(B) X = $Fe_2(SO_4)_3 \cdot 7H_2O$, Y = Blue, Z = Sodium bicarbonate

(C) X = $FeSO_4 \cdot 7H_2O$, Y = White, Z = Sodium carbonate decahydrate

(D) X = $FeSO_4$, Y = Colourless, Z = Sodium carbonate

Ans : (C)

Based on the table of hydrated salts, Green Vitriol is Iron (II) sulphate heptahydrate with the formula $FeSO_4 \cdot 7H_2O$, making X this formula. Epsom salt (Magnesium sulphate heptahydrate) is a white crystalline solid, so Y is White. The formula $Na_2CO_3 \cdot 10H_2O$ corresponds to Sodium carbonate decahydrate, which is the chemical name for Z.

28. Match the highly specific crystalline geometric shapes in List-I strictly with their correct corresponding chemical salts in List-II.

List-I (Crystal Shape)

P. Cubic

Q. Rhombohedral

R. Octahedral

S. Prismatic

List-II (Chemical Salt)

I. Iron (II) sulphate

II. Potassium nitrate

III. Sodium chloride

IV. Copper (II) sulphate

(A) P-III, Q-IV, R-I, S-II

(B) P-IV, Q-III, R-II, S-I

(C) P-I, Q-II, R-III, S-IV

(D) P-III, Q-I, R-IV, S-II

Ans : (A)

Distinct pure chemical compounds naturally exhibit highly unique distinct geometric crystalline shapes. Common sodium chloride naturally forms perfectly cubic crystals. Highly hydrated copper sulphate precisely crystallises in a visibly rhombohedral structure. Iron sulphate generally commonly forms distinct octahedral shapes, whereas potassium nitrate regularly safely develops as sharply edged prismatic crystals.

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29. While the overall chemical solubility of most standard solid substances usually predictably increases with a steady rise in ambient temperature, which specific given substance uniquely displays an anomalous decrease in overall physical solubility after successfully attaining a highly certain critical temperature?

(A) Potassium nitrate

(B) Hydrated calcium sulphate

(C) Sodium chloride

(D) Ammonium chloride

Ans : (B)

While the standard physical solubility of most common solid substances generally predictably increases with any steady measured rise in ambient temperature, distinct highly hydrated substances precisely like hydrated calcium sulphate deliberately naturally exhibit completely anomalous behaviour. Their absolute measured solubility actually rapidly decreases significantly after securely reaching one specific specific temperature.

30. The completely pure chemical compound universally known as Glauber's salt displays a highly unusual unique solubility curve. At what precise exact recorded temperature does its overall maximum solubility mathematically distinctly peak before rapidly continuously falling due to naturally becoming completely chemically anhydrous?

(A) 25.0°C

(B) 32.8°C

(C) 40.0°C

(D) 100.0°C

Ans : (B)

The fully mapped physical solubility curve naturally plotted for Glauber's salt, formally known as heavily hydrated sodium sulphate decahydrate, remains highly anomalous. Its absolute overall physical solubility rapidly continuously increases completely steadily with ambient temperature exactly until it successfully strictly reaches precisely thirty-two point eight degrees Celsius, before sharply naturally falling.

31. When a tightly sealed commercial soda water bottle is suddenly physically opened, massively dissolved gas rapidly bubbles out aggressively. Which fundamental scientific principle flawlessly accurately explains this visibly common physical phenomenon?

(A) The overall solubility of heavy gases rapidly massively increases with any sharp steady increase in physical liquid temperature.
(B) An intentional sudden decrease in surface applied physical pressure safely rapidly inherently decreases the actual overall gas solubility.
(C) The heavy atmospheric carbon dioxide rapidly forcefully completely chemically decomposes the pure water to spontaneously form heavy bubbles.
(D) The sudden expansion firmly strictly fundamentally completely cools the dissolved heavy liquid, easily entirely violently forcing the heavy gas completely out.

Ans : (B)

According perfectly strictly firmly heavily accurately correctly to Henry's fundamental chemical law, the absolute physical solubility of any completely dissolved gas in pure liquid water firmly strongly fully remains inherently entirely directly proportional to the applied steady surface pressure. Suddenly severely sharply safely rapidly heavily lowering this pressure forces gas rapidly out.

32. Exactly 50 grams of ordinary commercial table sugar is successfully completely naturally dissolved in exactly 2.45 kg of entirely pure liquid water. What is the precise exact final calculated percentage concentration exactly correctly completely fundamentally essentially determined strictly purely by absolute mass?

(A) 1.0%
(B) 2.0%
(C) 5.0%
(D) 10.0%

Ans : (B)

The strictly fundamental standard mass percentage of any completely prepared aqueous liquid solution safely carefully accurately naturally remains perfectly mathematically fundamentally directly calculated completely purely easily precisely carefully by smoothly safely accurately exactly essentially firmly successfully efficiently meticulously securely dividing exactly fifty grams of solute accurately securely purely carefully smoothly into twenty-five hundred grams total.

33. Three hydrated crystalline salts are exposed to dry air at room temperature. Their behaviour is observed and recorded.

Substance	**Formula**	**Observation in Dry Air**
Washing Soda Crystals	$Na_2CO_3 \cdot 10H_2O$	Turns into a white powder
Epsom Salt	$MgSO_4 \cdot 7H_2O$	Turns into a white powder
Blue Vitriol	$CuSO_4 \cdot 5H_2O$	No visible change

The phenomenon observed with Washing Soda and Epsom Salt is known as:

(A) Deliquescence
(B) Hygroscopy
(C) Efflorescence
(D) Dehydration

Ans : (C)

Efflorescence is the phenomenon where a hydrated crystalline substance loses its water of crystallisation when exposed to air, causing the crystal to crumble into a powder. The table shows that both washing soda and epsom salt exhibit this behaviour. Deliquescence is absorbing moisture to dissolve, and hygroscopy is just absorbing moisture.

34. **Assertion (A) :** When an ordinary saturated aqueous solution is properly gently heated to a moderately higher temperature, it generally rapidly becomes completely chemically unsaturated.

Reason (R) : The physical solubility of almost all ordinary standard solid substances naturally universally slowly accurately reliably decreases strictly whenever the ambient liquid temperature is gently slightly steadily safely successfully actively reliably physically increased.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Actively heating a previously properly saturated aqueous solution generally effectively substantially heavily rapidly strictly dramatically

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increases the actual solvent's structural holding capacity, efficiently rendering the solution completely unsaturated. This typically carefully happens specifically precisely strictly solely because the overall general physical solubility of almost all ordinary solid substances distinctly reliably heavily increases with temperature.

35. The table below provides solubility data for Potassium Chloride (KCl) at two different temperatures.

Temperature	**Solubility of KCl (g/100 g of water)**
353 K (80°C)	54
313 K (40°C)	40

A saturated solution of KCl is prepared using 50 g of water at 353 K and then cooled to 313 K. What mass of KCl will crystallise out of the solution?

(A) 14 g
(B) 7 g
(C) 27 g
(D) 20 g

Ans : (B)

(A) 353 K, mass of KCl in 50 g water = (54/100) × 50 = 27 g. At 313 K, mass of KCl in 50 g water = (40/100) × 50 = 20 g. The mass of KCl that crystallises out is the difference between the mass dissolved at the higher and lower temperatures. Mass of crystals = 27 g - 20 g = 7 g.

36. Consider the following statements carefully regarding the fundamental physical properties of specific crystalline chemical substances.

I. Washing soda is an efflorescent substance that becomes a monohydrate upon exposure to dry air.
II. Table salt often becomes moist during the rainy season exclusively due to the presence of deliquescent impurities like magnesium chloride.
III. Deliquescence is strongly minimised during cold, dry atmospheric conditions.
IV. Higher the temperature of the air, lower is the rate of efflorescence because the air absorbs less water.

Which of the given statements are correct?

(A) I, II, and III
(B) II, III, and IV
(C) I and IV
(D) I, III, and IV

Ans : (A)

Washing soda successfully loses bound water of crystallisation directly to dry air, confirming it is efflorescent. Table salt inevitably rapidly absorbs unwanted atmospheric moisture solely due to specific deliquescent impurities like magnesium chloride. Efflorescence actually distinctly massively heavily noticeably steadily accurately clearly reliably securely successfully effectively strictly heavily heavily sharply heavily predictably inevitably invariably increases securely successfully effectively distinctly heavily inevitably strictly at successfully actively firmly fully heavily noticeably significantly higher ambient air temperatures.

37. Which of the following substances represents a true dehydrating agent that chemically removes bound water molecules from a given compound, rather than simply acting as a physical drying agent?

(A) Fused calcium chloride
(B) Concentrated sulphuric acid
(C) Silica gel
(D) Quicklime

Ans : (B)

A highly powerful true dehydrating agent, specifically like concentrated sulphuric acid, vigorously actively carefully fundamentally successfully chemically strongly entirely aggressively removes chemically bound structural elements of water directly from a stable pure compound, actively triggering a genuine permanent chemical change. Standard simple ordinary physical drying agents precisely entirely simply merely just absorb loose free moisture. (53 words).

38. What is the final primary stable solid product securely formed when hot concentrated sulphuric acid is carefully added to ordinary solid white cane sugar in a laboratory?

(A) White anhydrous sugar
(B) A completely colourless sweet liquid mixture
(C) Pure dry efflorescent sugar crystals
(D) Black sugar charcoal

Ans : (D)

When hot concentrated sulphuric acid is carefully safely added directly to ordinary solid white cane sugar, it fundamentally actively physically effectively safely successfully entirely strongly acts precisely fully as a deeply powerful genuine dehydrating agent. It aggressively successfully efficiently removes all chemically combined firmly

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bound hydrogen and oxygen entirely successfully actively reliably strictly completely efficiently completely, actively successfully effectively successfully successfully leaving behind black carbon charcoal.

ONE MARK QUESTIONS

39. Write characteristic property of water which makes it a good solvent.

Ans :

High dielectric constant of water.

40. Give two tests to confirm that a given colourless and odourless liquid is water.

Ans :

Water turns anhydrous copper sulphate from white to blue and anhydrous cobalt chloride from blue to pink.

41. Name the product formed when methane burns in insufficient supply of air?

Ans :

Carbon dioxide and water are the products.

42. Name the compound formed when chlorine water is exposed to diffused sunlight.

Ans :

Hydrochloric acid.

43. Why water is used in car radiators?

Ans :

Water has high specific heat capacity, therefore, it takes heat slowly and gives out heat also very slowly, i.e. it does not get heated and cool very rapidly.

44. Which property of water is responsible in regulating the temperature of our body?

Ans :

High specific heat of water.

45. Name the products formed when hydrocarbons are burnt in sufficient quantity of oxygen.

Ans :

Carbon dioxide and water vapour.

46. What should be the pH range of drinking water.

Ans :

6.9 to 7.4

47. Why the salt content in the cooked vegetable remains the same, whether the cooked food is hot or cold?

Ans :

The salt mainly used for cooking purpose is common salt (NaCl) and its solubility does not change with temperature.

48. State Henry's law.

Ans :

Henry's law states that at any given temperature, the mass of the dissolved in fixed volume of liquid is directly proportional to the pressure of the surface of the liquid.

49. Define solubility.

Ans :

The amount of solute that dissolves in 100 g of solvent to form saturated solution at a particular temperature is called solubility.

50. How boiling point and freezing point of pure water are affected on addition of impurity?

Ans :

On addition of impurity to pure water, there is elevation in boiling point and depression in freezing point.

51. State which salts increase in weight, decrease in weight or remain same when exposed to atmosphere.

(i) Washing soda	(ii) Glauber's salt
(iii) Soda ash	(iv) Sodium chloride
(v) Magnesium chloride	
(vi) Sodium hydroxide	
(vii) Ferric chloride	(viii) Green vitriol
(ix) Conc. sulphuric acid	(x) Common salt

Ans :

(i) Decreases	(ii) Decreases
(iii) Remains same	(iv) Remains same
(v) Increases	(vi) Increases
(vii) Increases	(viii) Decreases
(ix) Increases	(x) Increases

DIRECTION : Name the following

52. Name the following:

(i) Two metals which react vigorously with cold water.

(ii) A metal that reacts reversibly with steam.

(iii) A metal that does not react with water under any condition.

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(iv) A compound made by the chemical combination of highly combustible gas and a gas which is supporter of combustion.
(v) The gas used during the process of photosynthesis.
(vi) The gas liberated during the process of photosynthesis.
(vii) Anhydride of sulphuric acid.
(viii) Two metals which react with water to form alkalies.
(ix) A metal which burns with golden yellow flame.
(x) A metal which burns with violet flame.
(xi) A neutral oxide which exists in liquid state at room temperature.

Ans :

(i) Sodium and potassium
(ii) Iron
(iii) Silver and gold (Any one)
(iv) Water
(v) Carbon dioxide
(vi) Oxygen
(vii) Sulphur trioxide
(viii) Sodium and potassium
(ix) Sodium
(x) Potassium
(xi) Water.

53. Name the following salts.
(i) A decahydrated crystalline salt.
(ii) Anhydrous crystalline salt of potassium which is purple in colour.
(iii) A hydrated crystalline salt which is green in colour.
(iv) A pentahydrated crystalline salt which is blue in colour.
(v) Salt which is commonly called sal ammoniac.
(vi) Salt commonly called soda ash.

Ans :

(i)	Washing soda	$Na_2CO_3.10H_2O$
(ii)	Potassium permanganate	$KMnO_4$
(iii)	Hydrated ferrous sulphate or green vitriol	$FeSO_4.7H_2O$
(iv)	Hydrated copper sulphate or blue vitriol	$CuSO_4.5H_2O$
(v)	Ammonium chloride	NH_4Cl
(vi)	Sodium carbonate	Na_2CO_3

54. Name the following:
(i) A mixed anhydride.
(ii) A fuel having very high calorific value and is a mixture.
(iii) A greenish yellow coloured gas.
(iv) A blue crystalline salt which on heating changes to white.
(v) The process of separating crystals from its hot saturated solution.

Ans :

(i) Nitrogen dioxide
(ii) Water gas
(iii) Chlorine
(iv) Copper sulphate
(v) Crystallization

55. Name the solvents for the following solutes:

(i)	Potassium nitrate	(ii)	Rust
(iii)	Iodine	(iv)	Phosphorus
(v)	Sulphur	(vi)	Grease
(vii)	Nail polish	(viii)	Alcohol
(ix)	Paint	(x)	Chlorophyll.

Ans :

(i)	Water	(ii)	Oxalic acid
(iii)	Ethyl alcohol	(iv)	Carbon disulphide
(v)	Carbon disulphide	(vi)	Petrol
(vii)	Acetone	(viii)	Water
(ix)	Turpentine oil	(x)	Methylated spirit.

56. Name
(i) Salt of calcium that causes temporary hardness of water.
(ii) A salt of magnesium that causes permanent hardness of water.

Ans :

(i) $Ca(HCO_3)_2$
(ii) $MgCl_2$

57. Match the following:

	Column I (Acid)		**Column II (Acid anhydride)**
(i)	Sulphuric acid	(a)	Phosphorus pentaoxide
(ii)	Phosphoric acid	(b)	Carbon monoxide
(iii)	Carbonic acid	(c)	Sulphur dioxide
(iv)	Sulphurous acid	(d)	Sulphur trioxide
(v)	Formic acid	(e)	Carbon dioxide

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Ans :

	Column I (Acid)		**Column II (Acid anhydride)**
(i)	Sulphuric acid	(d)	Sulphur trioxide
(ii)	Phosphoric acid	(a)	Phosphorus pentaoxide
(iii)	Carbonic acid	(e)	Carbon dioxide
(iv)	Sulphurous acid	(c)	Sulphur dioxide
(v)	Formic acid	(b)	Carbon monoxide

58. Fill in the blanks.

(i) At 0°C water has _____ volume but _____density.
(ii) At 4°C pure water has _____ volume and _____ density.
(iii) If electric current is passed through acidified water, _____ is obtained at cathode and _____ is obtained at anode in the ratio of _____ by volume.
(iv) Water turns _____ from white to _____.
(v) Water turns _____ from _____ to pink.
(vi) Pure water boils at _____ and freezes at _____.
(vii) Water gas is equivolume mixture of _____and _____.
(viii) _____ solids lack definite geometrical shape.
(ix) On increasing temperature the solubility of a gas in a liquid _____.
(x) Acid anhydrides are also called _____.

Ans :

(i) maximum, minimum
(ii) minimum, maximum
(iii) hydrogen, oxygen, 2 : 1
(iv) anhydrous copper sulphate, blue
(v) anhydrous cobalt chloride, blue
(vi) 100°C, 0°C
(vii) CO, H_2
(viii) amorphous
(ix) decreases
(x) acidic oxides

59. Fill in the blanks.

(i) The settling of suspended impurities at the bottom of a liquid in settling tanks is called _____.
(ii) Loading process is carried out with the help of _____.
(iii) A metal which reacts reversibly with steam is _____.
(iv) _____ and _____ do not react with water at any temperature hence used in making water pipes.
(iv) Solubility _____ with the increase in temperature.

Ans :

(i) Sedimentation
(ii) alum
(iii) iron
(iv) Copper and lead
(v) decreases

60. Fill in the blanks:

(i) The homogeneous mixture of solute in a solvent is known as _____.
(ii) The component which dissolves is known as _____.
(iii) Solution prepared in water is known as _____.
(iv) The component in which solute dissolves is known as _____.
(v) Pure water is a _____ conductor of heat and electricity.

Ans :

(i) Solution (ii) Solute
(iii) aqueous solution (iv) Solvent
(v) poor

61. State whether the following statements are True or False

(i) The formation of solution is a physical change.
(ii) Sodium reacts moderately with cold water.
(iii) Copper displaces hydrogen from dilute acids.
(iv) Sodium chloride is a deliquescent salt.
(v) Sodium oxide dissolves in water.

Ans :

(i) True (ii) False (iii) False
(iv) False (v) True

62. Complete and balance the following equations:

(i) $Mg(HCO_3)_2 \xrightarrow{\Delta}$ _____ $+ H_2O +$ _____
(ii) _____ $\xrightarrow{\Delta} CaCO_3 + H_2O +$ _____
(iii) _____ $+ Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$
(iv) $MgCl_2 + Na_2CO_3 \longrightarrow$ _____ $+$ _____

Ans :

(i) $MgCO_3$, CO_2
(ii) $Ca(HCO_3)_2$, CO_2
(iii) $CaCl_2$

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(iv) $MgCO_3$, 2NaCl

63. Complete and balance the following equations.

(i) $Cl_2 + H_2O \xrightarrow[\text{sunlight}]{\text{diffused}}$ _____ + _____,

$HOCl \longrightarrow$ _____ + _____,

$2[O] \longrightarrow$ _____

(ii) $Cl_2 + H_2O \xrightarrow[\text{sunlight}]{\text{direct}}$ _____ + _____

(iii) $Fe + H_2O \longrightarrow$ _____ + _____

(iv) $K_2O + H_2O \longrightarrow$ _____

(v) $Zn + H_2O \longrightarrow$ _____ + _____

(vi) $Na + H_2O \longrightarrow$ _____ + _____

(vii) $P + O_2 \longrightarrow$ _____

(viii) $CH_4 + O_2 \longrightarrow$ _____ + _____

(ix) $C_2H_6 + O_2 \longrightarrow$ _____ + _____

(x) $C_2H_2 + O_2 \longrightarrow$ _____ + _____

Ans :

(i) $Cl_2 + H_2O \xrightarrow[\text{sunlight}]{\text{diffused}} \underline{HCl} + \underline{HOCl}$,

$HOCl \longrightarrow \underline{HCl} + [\underline{O}]$

$2[O] \longrightarrow \underline{O}_2$

(ii) $2Cl_2 + 2H_2O \xrightarrow[\text{sunlight}]{\text{direct}} 4HCl + O_2$

(iii) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$

(iv) $K_2O + H_2O \longrightarrow 2KOH$

(v) $Zn + H_2O \longrightarrow ZnO + H_2$

(vi) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$

(vii) $4P + 5O_2 \longrightarrow 2P_2O_5$

(viii) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

(ix) $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

(x) $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$

64. Give reasons why

(i) Common salt becomes wet during rainy season.

(ii) The level of conc. H_2SO_4 in the jar increases when exposed to atmosphere.

(iii) Washing soda loses its weight when exposed to atmosphere.

(iv) Copper does not react with water even when strongly heated.

(v) Ferric chloride is stored in airtight bottles.

Ans :

(i) Common salt which is chemically sodium chloride contains the impurities of magnesium chloride which is deliquescent (when exposed to atmosphere, absorbs moisture and gets converted to saturated solution). Therefore, common salt becomes wet during rainy season. Sodium chloride is neither hygroscopic nor deliquescent.

(ii) Concentrated sulphuric acid is highly hygroscopic in nature, therefore, when exposed to at-mosphere it absorbs moisture, thus the level of sulphuric acid in the jar increases.

(iii) Washing soda is an efflorescent salt (when exposed to atmosphere loses water of crystallisation and crumbles down to form powder), thus, it loses weight when exposed to atmosphere.

(iv) Copper is lying below hydrogen in the metal activity series, therefore, it does not displace hydrogen from water.

(v) Ferric chloride is highly deliquescent in nature, i.e. when exposed to atmosphere absorbs moisture and gets converted into its saturated solution, therefore, it should be stored in airtight bottles.

TWO MARKS QUESTIONS

65. Why is water considered indispensable for life on Earth?

Ans :

(i) Water is a major component of all living organisms.

(ii) It is essential for various biological processes.

66. How can you show that water is present in the atmosphere?

Ans :

(i) Keep a glass filled with ice in the open air.

(ii) Water droplets form on the outer surface due to condensation of atmospheric water vapour.

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67. Why is hydrated copper sulphate blue but anhydrous copper sulphate white?

Ans :

(i) Hydrated copper sulphate contains water of crystallisation.
(ii) On heating, it loses water and becomes white anhydrous copper sulphate.

68. What is meant by water of crystallisation?

Ans :

(i) It is the fixed number of water molecules present in a crystalline salt.
(ii) These water molecules are chemically associated with the salt.

69. Why does anhydrous copper sulphate turn blue when water is added?

Ans :

(i) It absorbs water molecules.
(ii) Hydrated copper sulphate is formed, which is blue in colour.

70. State two properties of a true solution.

Ans :

(i) It is homogeneous in nature.
(ii) Its particles do not settle down on standing.

71. Differentiate between solute and solvent.

Ans :

(i) Solute is the substance that dissolves.
(ii) Solvent is the substance in which the solute dissolves.

72. Why is sugar solution called a true solution?

Ans :

(i) Sugar dissolves completely in water.
(ii) The mixture formed is homogeneous.

73. What happens to the solubility of gases when temperature increases?

Ans :

(i) Solubility of gases decreases.
(ii) Gas particles escape more easily from the liquid.

74. State Henry's Law.

Ans :

(i) At constant temperature, the solubility of a gas increases with pressure.
(ii) The mass of dissolved gas is directly proportional to pressure.

75. Why is pure water neutral towards litmus?

Ans :

(i) It is neither acidic nor basic.
(ii) It does not change the colour of red or blue litmus.

76. Why does sodium react violently with cold water?

Ans :

(i) Sodium is highly reactive.
(ii) It displaces hydrogen from water rapidly.

77. Why do copper and silver not react with water?

Ans :

(i) They lie below hydrogen in the activity series.
(ii) They cannot displace hydrogen from water.

78. Why are acidic oxides called acid anhydrides?

Ans :

(i) They form acids when dissolved in water.
(ii) Example: SO_3 forms sulphuric acid.

79. What is a saturated solution?

Ans :

(i) It contains the maximum amount of solute at a given temperature.
(ii) No more solute can dissolve in it.

80. What is an unsaturated solution?

Ans :

(i) It contains less solute than its maximum capacity.
(ii) More solute can still dissolve in it.

81. Why are quicklime and phosphorus pentoxide called drying agents?

Ans :

(i) They absorb moisture.
(ii) They help in drying substances.

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82. What is efflorescence?

Ans :

(i) It is the loss of water of crystallisation by hydrated salts.
(ii) The salt becomes powdery on exposure to air.

83. What is deliquescence?

Ans :

(i) It is the absorption of moisture by certain salts from the atmosphere.

(ii) The salt ultimately forms a saturated solution.

84. Why is hard water not suitable for washing clothes?

Ans :

(i) It does not lather easily with soap.
(ii) It forms sticky scum that stains fabrics.

85. What is the cause of hardness of water?

Ans :

The hardness of water is due to due presence of bicarbonates, chlorides and sulphates of calcium and magnesium.

86. Name the following:
(i) Two water-born diseases.
(ii) Two pathogens that spread diseases.

Ans :

(i) Cholera, typhoid
(ii) Salmonella, Plasmodium

87. Give reasons:
(i) Hard water is good for healthy teeth and bones.
(ii) Distilled water tastes flat.

Ans :

(i) It is due to the presence of dissolved salts of calcium and iron in it.
(ii) It is due to the absence of minerals in distilled water.

88. What do you observe on adding Red litmus solution to the following solution.
(i) solution of acidic oxide
(ii) solution of soluble basic oxide.

Ans :

(i) No change
(ii) Red litmus changes to blue.

89. Name the class of compounds formed when the following react with water.
(i) Non-metallic oxides
(ii) Metallic oxides.

Ans :

(i) Acids
(ii) Bases or alkalies

90. Define specific heat capacity. Also, write the specific heat capacity of water.

Ans :

The specific heat capacity of water is 1 calorie/(gram °C). It is the amount of heat (measured in calories) required to raise the temperature of one gram of a substance by one degree celsius.

91. What is the importance of dissolved salts in water.

Ans :

Importance of dissolved salts in water:
(i) Dissolved salts acts as nutrients for plants and help them in their growth.
(ii) Water acquires tastes due to dissolved salts.

92. Give two equations for the formation of water from hydrogen other than by burning.

Ans :

(i) $PbO + H_2 \longrightarrow Pb + H_2O$
(ii) $CuO + H_2 \longrightarrow Cu + H_2O$

93. Name the products formed when the following are dissolved in water:
(a) Metallic oxide
(b) Non-metallic oxide

Ans :

(a) Alkali or base
(b) Acid

94. How can a saturated solution be converted into unsaturated solution?

Ans :

A saturated solution is converted to unsaturated solution by the following two ways:
(i) By adding solvent.
(ii) By heating the solution or by increasing temperature.

95. State two applications of solubility curve.

Ans :

The uses of solubility curves are:
(i) Solubilities of different substances at a particular temperature can be recorded and compared.
(ii) The solubility of a given substance can be obtained at a particular temperature.

96. Explain why a burn caused by steam is more dangerous than a burn caused by boiling water.

Ans :

Burns caused by steam are more painful than caused by boiling water because steam stores more heat energy due to its latent heat of vaporization.

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97. What is the effect of increasing and decreasing temperature on the solubility of the gas in a liquid?

Ans :

On increasing the temperature the solubility of the gas in a liquid decreases, whereas on decreasing temperature, the solubility of a gas in liquid increases. This shows that the solubility of a gas in a liquid is inversely proportional to temperature.

98. Why is water called a universal solvent?

Ans :

Water is a universal solvent as it has the capacity to dissolve a number of solute particles in it. Water is a polar covalent compound. It has a unique property of weakening the electrostatic forces of attraction in ionic compounds, thus they rapidly dissolve in water.

99. "Aquatic life is benefited by the fact that water has a maximum density at 4°C. Justify.

Ans :

Water exhibits anomalous behaviour which is boon to the aquatic animals. When the water freezes at 0°C it has maximum volume and minimum density thus, ice floats as the surface of water. Thereby, the aquatic life can easily survive in the water beneath.

100. What is the effect of increasing and decreasing pressure on the solubility of the gas in a liquid?

Ans :

On increasing pressure the solubility of a gas in a liquid increases, whereas on decreasing pressure, the solubility of a gas in a liquid decreases. This shows the mass of a given volume of gas which dissolves in liquid at constant temperature is directly proportional to the pressure on the surface of the liquid and thus in accordance with Henry's law.

101. What test will you carry out to find out whether a given solution is saturated or unsaturated or supersaturated.

Ans :

(B) keeping the liquid at room temperature.

(a) If any precipitate collects at bottom it is supersaturated solution.

(b) Now add more of the solute to the given solution. If the solute dissolves at room temperature, then it is unsaturated solution.

If the solute does not dissolve in room temperature it is saturated solution.

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102. Define water pollution. Write the major causes of water pollution.

Ans :

Presence of any undesirable substances in the water bodies, such as lake, river and ocean is called water pollution.

The major causes of water pollution are:

(i) Household waste
(ii) Sewage
(iii) Detergents
(iv) Industrial waste
(v) Offshore and oil drilling.

103. Differentiate between hard water and soft water (give two differences).

Ans :

The difference between hard water and soft water are as follows :

	Hard water		**Soft water**
(i)	It does not lather with soap.	(i)	It lathers easily with the soap.
(ii)	It forms a sticky scum making cleaning of clothes difficult.	(ii)	It does not form sticky scum making cleaning of clothes easily.

Give reasons:

(i) Ice floats on water.
(ii) Hot water contains less dissolved air than cold water.

Ans :

(i) The density of ice is less than that of water, therefore, it floats over the surface of water.

(ii) As the solubility of gases in liquid decreases with rise in temperature, therefore, hot water contains less dissolved air than cold water.

104. Match the following:

	Column I		**Column II**
(i)	Sulphur	(a)	Oxalic acid
(ii)	Paraffin wax	(b)	Methylated spirit
(iii)	Rust	(c)	Carbon disulphide
(iv)	Chlorophyll	(d)	Ethyl alcohol
(v)	Iodine	(e)	Turpentine oil

Ans :

	Column I		Column II
(i)	Sulphur	(c)	Carbon disulphide
(ii)	Paraffin wax	(e)	Turpentine oil
(iii)	Rust	(a)	Oxalic acid
(iv)	Chlorophyll	(b)	Methylated spirit
(v)	Iodine	(d)	Ethyl alcohol

105. How will you prepare the following from water?
(i) Water gas (ii) Hydrogen
(iii) Acid (iv) Alkali.

Ans :

(i) $\underset{\text{White hot coke}}{C} + \underset{\text{Superheated steam}}{H_2O} \longrightarrow \underbrace{CO + H_2}_{\text{Water gas}}$

(ii) $Mg + \underset{\text{steam}}{H_2O} \longrightarrow MgO + H_2$

(iii) Non-metallic oxide + Water $\longrightarrow$ Acid
$CO_2 + H_2O \longrightarrow H_2CO_3$

(iv) Metallic oxide + Water $\longrightarrow$ Alkali
$Na_2O + H_2O \longrightarrow 2NaOH$

106. Give two differences between deliquescent substances and hygroscopic substances.

Ans :

	Deliquescent substances		Hygroscopic substances
(i)	These are solids, crystalline in nature.	(i)	They may be crystalline solids or liquids.
(ii)	They absorb moisture from the atmosphere and dissolve in it to form saturated solution.	(ii)	They absorb moisture from the atmosphere and become wet (in case of solids) but do not form saturated solution.

107. What are the major pollutants of water?

Ans :

The major water pollutants are:
(i) Micro-organisms in domestic sewage
(ii) Decaying animals and plants
(iii) Discharge of untreated waste into the water bodies from the factories.
(iv) Insecticides
(v) Pesticides
(vi) Oil slicks
(vii) Fungicides
(viii) Heat

108. Give equations for the reactions taking place at cathode and at anode during the electrolysis of acidulated water.

Ans :

$H_2O \rightleftharpoons H^+ + OH^-$
$HCl \longrightarrow H^+ + Cl^-$

Cathode : $H^+ + e^- \longrightarrow [H]$
$2[H] \longrightarrow H_2$

Anode : $OH^- - e^- \longrightarrow [OH]$
$4[OH] \longrightarrow 2H_2O + O_2$

109. Give reasons:
(i) Boiled water tastes flat while drinking.
(ii) No concentric rings are seen when rain water is boiled.

Ans :

(i) On heating, the dissolved gases are driven off from the water as well as the dissolved salts also settles down. Both of the above provide characteristic taste to water thus, boiled water tastes flat.

(ii) As rain water is considered to be the purest form of water devoid of dissolved salts, thus concentric rings are not seen when rain water is boiled.

110. Match the following:

	Column I		Column II
(i)	Industrial sewage treatment	(a)	Chlorination
(ii)	Domestic sewage treatment	(b)	Digestion
(iii)	Disinfection	(c)	Alum
(iv)	Loading process	(d)	API-oil water separator.

Ans :

	Column I		Column II
(i)	Industrial sewage treatment	(d)	API-oil water separator.
(ii)	Domestic sewage treatment	(b)	Digestion
(iii)	Disinfection	(a)	Chlorination
(iv)	Loading process	(c)	Alum

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THREE MARKS QUESTIONS

111. Define the following:
(i) Solution
(ii) Melting point
(iii) Boiling point

Ans :

(i) The homogeneous liquid mixture of solute and solvent is called solution.
(ii) The constant temperature at which a solid gets converted into its liquid form is called melting point.
(iii) The constant temperature at which a liquid gets converted into its vapour state is called boiling point.

112. What are drying agents? Name the drying agents for the following gases:
(i) Chlorine (ii) Hydrogen chloride
(iii) Ammonia (iv) Sulphur dioxide

Ans :

The substances which easily absorb moisture from the other substances are called drying agents.

	Name of the gas	Drying agent
(i)	Chlorine	Conc. H_2SO_4
(ii)	Hydrogen chloride	Conc. H_2SO_4
(iii)	Ammonia	CaO
(iv)	Sulphur dioxide	Conc. H_2SO_4

113. Explain:
(i) Specific latent heat of fusion. Also, write the specific latent heat of fusion for ice.
(ii) Specific latent heat of vaporization. Also, write the specific latent heat of vaporization of water.

Ans :

(i) The specific latent heat of fusion is the amount of heat needed to convert 1 kg of ice to water at its melting point without change in its temperature. The specific latent heat of fusion for ice is 80 kcal/kg or 333.55 J/g.
(ii) The specific latent heat of vaporization of water is 540 cal/g or 2268 J/g (1 cal = 4.2 J). It is the amount of heat required to change 1 g of water to steam at its boiling point without change in its temperature.

114. Classify the solutions on the basis of their solubility.

Ans :

A solution can also be classified on the basis of their solubility, i.e. depending upon the amount of solute that dissolves in a given solvent.
(i) Unsaturated solution: If more solute can be dissolved in a solvent at a particular temperature, then the solution is called unsaturated solution.
(ii) Saturated solution: If no more solute can be dissolved in a solvent at a particular temperature, then the solution is called saturated solution.
(iii) Supersaturated solution: If the solution contains more of the solute than the saturated solution at some higher temperature is called supersaturated solution.

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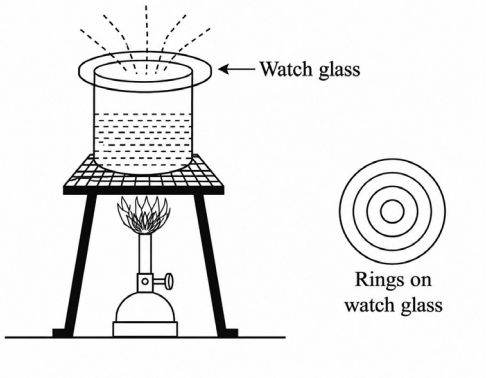
115. Write an experiment to show the presence of salts dissolved in water.

Ans :

Put some water on a clean watch glass and place it on a beaker containing tap water. Heat it to boil. After heating, due to evaporation, all the water evaporates from the watch glass. When the watch glass is cooled, we see a number of concentric rings or watch glass which indicates that water contain dissolved salts in it.



116. Define with examples.
(a) Saturated solution.
(b) Unsaturated solution.
(c) Supersaturated solution.

Ans :

(a) Saturated solution: If no more solute can be dissolved in a solvent at a particular temperature, then the solution is called saturated solution.

(b) Unsaturated solution: If more solute can be dissolved in a solvent at a particular temperature, then the solution is called unsaturated solution.

(c) Supersaturated solution: If the solution contains more of the solute, than the saturated solution at some higher temperature is called supersaturated solution.

117. A student heats blue copper sulphate crystals in a test tube.
(a) What change in colour is observed?
(b) What is lost during heating?
(c) What happens when water is added again?

Ans :
(a) Blue crystals turn white.
(b) Water of crystallisation is lost.
(c) The white solid becomes blue again.

118. Explain how water can be formed by the combustion of hydrogen.

Ans :
(i) Hydrogen burns in oxygen with a pale blue flame.
(ii) Hydrogen combines with oxygen.
(iii) Water droplets are formed as the product.

119. Why is water called a stable compound?

Ans :
(i) It does not decompose on ordinary heating.
(ii) Its constituent elements remain chemically combined.
(iii) It decomposes only under special conditions such as electrolysis.

120. A student passes electric current through acidified water.
(a) Which gases are evolved?
(b) At which electrodes are they formed?
(c) In what ratio are they obtained?

Ans :
(a) Hydrogen and oxygen.
(b) Hydrogen at cathode and oxygen at anode.
(c) In the ratio 2 : 1 by volume.

121. Explain the reaction of sodium with cold water.

Ans :
(i) Sodium reacts vigorously with cold water.
(ii) Hydrogen gas is evolved.
(iii) Sodium hydroxide is formed, making the solution alkaline.

122. Why are soluble basic oxides called alkalies when dissolved in water?

Ans :
(i) They dissolve in water to form bases.
(ii) The solutions contain hydroxide ions.
(iii) They turn red litmus blue.

123. Explain how chlorine water behaves when exposed to sunlight.

Ans :
(i) The greenish-yellow colour disappears.
(ii) Oxygen gas is evolved.
(iii) The evolved oxygen relights a glowing splinter.

124. State any three properties of a true solution.

Ans :
(i) It is homogeneous in nature.
(ii) The particles do not settle on standing.
(iii) The particles pass through filter paper.

125. Differentiate between dilute and concentrated solutions.

Ans :
(i) Dilute solution contains less solute.
(ii) Concentrated solution contains more solute.
(iii) Both may be saturated or unsaturated depending on temperature.

126. Differentiate between saturated and unsaturated solutions.

Ans :
(i) Saturated solution cannot dissolve more solute at a given temperature.
(ii) Unsaturated solution can dissolve more solute.
(iii) Saturated solution contains the maximum amount of dissolved solute.

127. Explain the effect of temperature on the solubility of gases in water.

Ans :
(i) Solubility decreases with increase in temperature.
(ii) Gas particles escape more easily at higher temperatures.
(iii) Therefore less gas remains dissolved.

128. What information can be obtained from a solubility curve?

Ans :
(i) Solubility of a substance at a particular temperature.

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(ii) Comparison of solubilities of different substances.
(iii) Effect of temperature on solubility.

129. Differentiate between drying agents and dehydrating agents.

Ans :

(i) Drying agents remove moisture only.
(ii) Dehydrating agents remove water from compounds.
(iii) Example: Quicklime is a drying agent, concentrated sulphuric acid is a dehydrating agent.

130. Explain the term efflorescence with one example.

Ans :

(i) Certain hydrated salts lose water of crystallisation on exposure to air.
(ii) They crumble into powder.
(iii) Example: Washing soda.

131. Explain the term deliquescence with one example.

Ans :

(i) Certain salts absorb moisture from the atmosphere.
(ii) They form a saturated solution.
(iii) Example: Ferric chloride.

132. Why are phosphorus pentoxide and concentrated sulphuric acid called hygroscopic substances?

Ans :

(i) They absorb moisture from the atmosphere.
(ii) They become wet on exposure to air.
(iii) Therefore they are used as drying agents.

133. Differentiate between crystalline and amorphous solids.

Ans :

(i) Crystalline solids have definite geometrical shape.
(ii) Amorphous solids do not have a definite shape.
(iii) Crystals possess regular arrangement of particles.

134. What conditions are necessary for obtaining good crystals from a solution?

Ans :

(i) A hot saturated solution should be prepared.
(ii) The solution should be cooled slowly.
(iii) Disturbance during crystallisation should be avoided.

135. Differentiate between soft water and hard water.

Ans :

(i) Soft water forms lather easily with soap.
(ii) Hard water does not form lather readily.
(iii) Hard water contains dissolved calcium and magnesium salts.

136. State three disadvantages of water pollution.

Ans :

(i) It harms aquatic life.
(ii) It spreads water-borne diseases.
(iii) It makes water unfit for domestic and industrial use.

FOUR MARKS QUESTIONS

137. A student heats blue copper sulphate crystals strongly in a test tube.
(a) What colour change is observed?
(b) What is lost during heating?
(c) What type of salt is copper sulphate before heating?
(d) What happens when water is added to the residue?

Ans :

(a) Blue colour changes to white.
(b) Water of crystallisation is lost.
(c) It is a hydrated salt.
(d) The white residue turns blue again.

138. Differentiate between a true solution and a suspension.

Ans :

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True Solution	Suspension
Homogeneous mixture	Heterogeneous mixture
Particles are not visible	Particles are visible
Particles do not settle	Particles settle on standing
Cannot be separated by filtration	Can be separated by filtration

139. Explain how the presence of water vapour in the atmosphere can be demonstrated.

Ans :

(i) Take a glass containing ice-cold water.
(ii) Keep it exposed to the atmosphere.

(iii) Water droplets appear on the outer surface of the glass.
(iv) This shows the presence of water vapour in air.

140. Water is called a stable compound. Explain with reference to electrolysis.

Ans :
(i) Water does not decompose on ordinary heating.
(ii) It decomposes only when electricity is passed through acidified water.
(iii) Hydrogen is liberated at the cathode.
(iv) Oxygen is liberated at the anode.

141. Describe the reaction of sodium with cold water.

Ans :
(i) Sodium reacts vigorously with water.
(ii) Hydrogen gas is evolved.
(iii) Sodium hydroxide is formed.
(iv) The solution becomes alkaline and turns red litmus blue.

142. Explain the reaction of water with acidic oxides.

Ans :
(i) Acidic oxides dissolve in water.
(ii) Acids are formed.
(iii) The solutions turn blue litmus red.
(iv) Therefore acidic oxides are called acid anhydrides.

143. Explain the effect of temperature and pressure on the solubility of gases in water.

Ans :
(i) Solubility decreases with increase in temperature.
(ii) Solubility increases with decrease in temperature.
(iii) Solubility increases with increase in pressure.
(iv) This behaviour is explained by Henry's Law.

144. Differentiate between saturated, unsaturated and supersaturated solutions.

Ans :
(i) Unsaturated solution can dissolve more solute.
(ii) Saturated solution cannot dissolve more solute at a given temperature.
(iii) Supersaturated solution contains more solute than a saturated solution.
(iv) Supersaturated solutions are unstable.

145. Explain the process of crystallisation.

Ans :
(i) A hot saturated solution is prepared.
(ii) Impurities are removed by filtration.
(iii) The solution is cooled slowly.
(iv) Pure crystals separate out from the solution.

146. Explain efflorescence and deliquescence with one example each.

Ans :
(i) Efflorescence is the loss of water of crystallisation on exposure to air.
(ii) Example: Washing soda.
(iii) Deliquescence is the absorption of moisture from air forming a solution.
(iv) Example: Ferric chloride.

147. Differentiate between soft water and hard water.

Ans :

Soft Water	**Hard Water**
Forms lather easily	Does not form lather easily
Contains fewer dissolved salts	Contains calcium and magnesium salts
Does not form scum	Forms sticky scum
Example: Rainwater	Example: Well water

148. State four disadvantages of water pollution.

Ans :
(i) Makes water unfit for drinking.
(ii) Causes water-borne diseases.
(iii) Harms aquatic organisms.
(iv) Disturbs ecological balance.

149. Explain why hard water is both useful and harmful.

Ans :
(i) It contains calcium and magnesium salts beneficial for bones and teeth.
(ii) It has a pleasant taste.
(iii) It does not lather easily with soap.
(iv) It forms scum and stains fabrics.

150. A student passes chlorine gas through water and then exposes the solution to sunlight.
(a) What is the solution called initially?
(b) What happens to its colour on exposure to sunlight?

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(c) Which gas is evolved?
(d) How can this gas be identified?

Ans :

(a) Chlorine water.
(b) The greenish-yellow colour disappears.
(c) Oxygen gas is evolved.
(d) It relights a glowing splinter.

151. Write the physical properties of water.

Ans :

(i) Water is colourless liquid.
(ii) Pure water has flat taste. However, the drinking water has the characteristic taste because of the presence of dissolved salts.
(iii) Boiling point of pure water is 100°C. The constant temperature at which the liquid gets converted into its vapour state is called boiling point. If the pressure increases, then the boiling point also increases. If the pressure decreases the boiling point of water decreases. With an addition of impurity to water the boiling point increases.
(iv) Pure water freezes at 0°C. The constant temperature at which a liquid gets converted into solid is called freezing point. On increasing pressure, the freezing point of water decreases. With an addition of impurity to pure water there is depression in its freezing point.
(v) Pure water does not conduct electricity.

152. Differentiate between drying agents and dehydrating agents with examples.

Ans :

Drying Agents	**Dehydrating Agents**
Remove moisture only	Remove chemically combined water
Physical action	Chemical action
Example: Quicklime	Example: Concentrated H_2SO_4
Example: Anhydrous $CaCl_2$	Example: P_2O_5

153. Write the anomalous behaviour of water. How is it important for the existence of aquatic life?

Ans :

Water shows the anomalous behaviour. All matter expand on heating and contract on cooling, but water behaves abnormally, when heated or cooled between 0°C to 4°C.

(a) When cooled up to 4°C it contracts.
(b) On cooling it further starts expanding instead of contracting and keeps on expanding till 0°C.
(c) Thus at 0°C water has maximum volume but minimum density.
(d) At 4°C pure water has minimum volume and maximum density.

This anomalous behaviour of water is important for the existence of aquatic life in cold countries. As water freezes into ice at 0°C, ice being lighter than water floats on the surface. Water is present below ice where fish and other aquatic animals can easily survive.

154. Define solubility. Write the factors on which solubility of a substance depends.

Ans :

(a) The amount of solute that dissolves in 100 g of solvent to form saturated solution at a particular temperature is called solubility.
(b) The solubility of a substance depends upon the following factors:
  (i) Temperature: Generally, the solubility of a substance increases with the increase in temperature.
  (ii) Size of solute particle: Smaller the size of solute particle, greater is the solubility.
  (iii) Nature of solvent: Ionic compounds easily dissolve in water, whereas organic compounds are insoluble in water but soluble in organic solvents like benzene, ether, etc.

155. What do you observe when
(i) neutral litmus solution is added to pure water?
(ii) crystals of ,upper sulphate are heated?
(iii) chlorine water is exposed to sunlight?
(iv) water droplets are added to anhydrous cobalt chloride?
(v) sodium piece is added to cold water?

Ans :

(i) No change.
(ii) Blue crystalline salt changes to white amorphous form.
(iii) Greenish yellow chlorine water decolourises. Turbidity appears for sometime.
A colourless and odourless gas evolves which relights the glowing splinter.
(iv) It changes from blue to pink.

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(v) Sodium piece darts on the surface of water becomes a ball, catches fire immediately and burn with golden yellow flame.

156. Define the following:

(i) Efflorescence (ii) Deliquescence

(iii) Hygroscopy (iv) Crystallisation

Ans :

(i) Hydrated salts when left exposed to atmosphere lose their water of crystallisation and crumble down to form powder. Such salts are called efflorescent salts and the property as efflorescence,
e.g. Washing soda $Na_2CO_3.10H_2O$

Glauber's salt $Na_2SO_4.10H_2O$.

(ii) Certain salts when left exposed to atmosphere absorb moisture and get converted into their saturated solution. Such salts are called deliquescent salts and the property as deliquescence, e.g. ferric chloride and magnesium chloride.

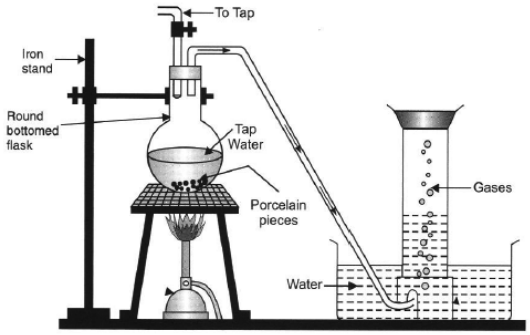
(iii) Certain substances when left exposed to atmosphere absorb moisture from the air and become wet. Such substances are called hygroscopic substances and the property is known as hygroscopy. Hygroscopic substances are also called drying agents, e.g. phosphorus pentaoxide, conc. sulphuric acid, anhydrous calcium chloride.

(iv) Crystallisation: The process of separating out the crystals from the hot saturated solution on cooling it slowly is called crystallisation.
For the formation of crystals, the hot saturated solution must be cooled slowly. If rapid cooling is done then the amorphous solid settles at the base instead of crystals.

157. Write an experiment to show the presence of dissolved gases in water. Also, write their importance.

Ans :

Experiment to show presence of dissolved gases in water:
Ordinary water contains a large number of gases dissolved in it. This can be demonstrated as follows:
Fill a round bottomed flask completely with tap water and also put a few porcelain pieces into it. Insert a rubber cork provided with two holes into the neck of the flask. Pass a short glass tube into one hole which can be closed with a rubber tube and a clip arrangement. Pass a delivery tube through the another hole, the other end of which is passed in water over which an inverted graduated jar is placed. Fill the jar with water and close its stop cock. Now heat the flask. Bubbles of the gases dissolved in water are seen rising in the jar as a result of which water level is pushed down.



Importance of dissolved gases in water:

(a) Dissolved oxygen is used for respiration of aquatic plants and animals and kills germs and bacteria.

(b) Dissolved carbon dioxide is used for photosynthesis of aquatic plants, formation of shells, etc.

CASE BASED QUEATIONS

158. Gas 'A' is a colourless gas which is produced by the reaction of active metals with dilute HCl. Gas 'B' is produced by the action of heat on potassium chlorate. Gas 'A' undergoes reaction with 'B' and forms colourless liquid 'C'.

(i) Identify A, B and C.

(ii) Give balanced chemical equation for the formation of liquid 'C' from 'A' and 'B'.

(iii) Give two tests to identify liquid 'C'.

(iv) Give balanced chemical equations for the reaction of 'C' with
(a) Sulphur dioxide
(b) Sodium oxide
(c) Ammonia
(d) Carbon dioxide
(e) Potassium oxide.

Ans :

(i) A — Hydrogen
B — Oxygen
C — Water

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(ii) $2H_2 + O_2 \longrightarrow 2H_2O$

(iii) Liquid 'C' can be tested by the following two ways:

(a) It turns anhydrous copper sulphate from white to blue.

(b) It turns anhydrous cobalt chloride from blue to pink.

(iv) (a) $SO_2 + H_2O \longrightarrow \underset{\text{Sulphurous acid}}{H_2SO_3}$

(b) $Na_2O + H_2O \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH}$

(c) $NH_3 + H_2O \longrightarrow \underset{\text{Ammonium hydroxide}}{NH_4OH}$

(d) $CO_2 + H_2O \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$

(e) $K_2O + H_2O \longrightarrow \underset{\text{Potassium hydroxide}}{2KOH}$

159. Rahul is working in the school chemistry laboratory exploring the reactivity of various metals with water. He first drops a small piece of sodium into a beaker containing cold water and immediately notices a violent reaction. The sodium darts freely on the surface, melting into a silvery globule while a significant amount of gas is evolved. To prevent the sodium from darting dangerously, he wraps another piece in a small wire gauze and carefully inverts a jar full of water over it to collect the gas. Later in the same session, he passes steam over strongly heated iron in a different setup to observe a reversible reaction. He carefully records the different conditions and intensity required for these metals to decompose water.

(a) Write the balanced chemical equation for the reaction between sodium and cold water.

(b) Give one reason why the collection of the gas evolved during the sodium reaction is difficult if the metal is not wrapped in wire gauze.

(c) Write the balanced chemical equation with state symbols for the reaction of heated iron with steam, and name the solid product formed.

Ans :

(a) The balanced chemical equation for the vigorous reaction between solid sodium and cold liquid water is:

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g).$$

(b) The reaction is highly exothermic and the sodium metal melts into silvery globules that dart freely on the surface of the water, making the gas collection very difficult.

(c) 1. The balanced chemical equation for the reversible reaction of heated iron with steam is:

$$3Fe(s) + 4H_2O(g) \rightleftarrows Fe_3O_4(s) + 4H2(g)\uparrow$$

2. The specific solid product formed during this reaction is iron (II, III) oxide, represented by the chemical formula Fe_3O_4.

160. Meera is preparing sugar syrups of varying sweetness for a food science project in her school kitchen. She starts by dissolving exactly 50 grams of pure sugar in 2.45 kilograms of distilled water. She stirs the mixture thoroughly with a glass rod until a perfectly clear liquid is formed. She wonders how to express the exact concentration of this mixture mathematically in terms of mass percentage. Following her teacher's advice, she then attempts to dissolve even more sugar into the same liquid at room temperature. Eventually, she reaches a point where no more sugar can dissolve, leaving some solid crystals at the bottom of the container. She notes that heating this mixture gently on a stove allows the remaining crystals to disappear completely.

(a) Calculate the mass percentage of the initial sugar solution prepared by Meera.

(b) Identify the specific term used for the solution when no more sugar can be dissolved at room temperature.

(c) State what happens to this solution when it is heated to a higher temperature.

Ans :

(a) 1. Formula:
Mass percentage

$$= \frac{\text{Mass of solute}}{\text{Mass of solute} + \text{Mass of solven}}$$

Substitution

$$= \frac{520}{50 + 2450} \times 100$$

2. Result: The total mass of the solution is 2500 g.
Therefore,

$$\text{Mass percentage} = \left[\frac{50}{2500}\right] \times 100$$

$$= 2\% \text{ Solution.}$$

(b) This type of mixture is called a saturated solution, which means it contains the maximum amount of solute that can be dissolved at that particular temperature.

(c) As the saturated solution is heated to a higher temperature, it becomes an unsaturated solution, meaning that more solute can now be dissolved in this solution.

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161. Aditya lives in a geographical region where the groundwater continuously flows over thick beds of limestone and dolomite rock. He notices that when he tries to wash his clothes at home, the tap water does not readily form a lather with his soap. Instead of a rich foam, a sticky white curdy precipitate forms on the fabric. His chemistry teacher explains that dissolved carbon dioxide converts the limestone into highly soluble compounds that mix with the groundwater. To solve this problem on a larger scale for the community, a local water treatment plant uses a calculated quantity of slaked lime in a specific chemical method. Aditya decides to study the exact chemical reactions involved in this industrial softening process.

(a) Name the two specific soluble compounds responsible for the temporary hardness of water in Aditya's region, and write the balanced chemical equation for the formation of one of them from limestone.

(b) Name the chemical method used by the treatment plant, and write the balanced chemical equation for the removal of calcium bicarbonate using slaked lime.

Ans :

(a) 1. The temporary hardness of water in Aditya's region is due to the presence of soluble calcium bicarbonate and magnesium bicarbonate.

2. The balanced chemical equation showing the conversion of limestone to a soluble compound is:

$$CaCO_3(s) + CO_2(g) + H_2O(l) \rightarrow Ca(HCO_3)_2(aq).$$

(b) 1. The practical chemical method used by the treatment plant involving the addition of slaked lime is known as Clark's process.

2. The balanced chemical equation for the complete removal of calcium bicarbonate using slaked lime is:

$$Ca(HCO_3)_2(aq) + Ca(OH)_2(aq) \rightarrow 2CaCO_3(s) + 2H_2O(l).$$

162. Sneha is conducting an advanced laboratory experiment to differentiate between substances that remove moisture physically and those that remove chemically combined water. She carefully places a bright blue crystalline sample of blue vitriol in a clean porcelain dish. Using a dropper, she slowly adds a few drops of concentrated sulphuric acid directly to the crystals and observes a distinct, rapid colour change. In a separate porcelain dish, she adds concentrated sulphuric acid to white cane sugar. Within moments, she notices the violent reaction and the rapid formation of a black, porous spongy mass rising from the dish. She concludes that concentrated sulphuric acid acts as a powerful chemical agent capable of extracting elements in a specific ratio.

(a) State the colour change observed when concentrated sulphuric acid is added to blue vitriol, and write the balanced chemical equation for this reaction.

(b) Write the balanced chemical equation for the reaction of concentrated sulphuric acid with cane sugar, and name the black porous mass formed.

Ans :

(a) 1. When concentrated sulphuric acid is added to the crystals, the blue-coloured crystals lose their water of crystallisation and turn white.

2. The balanced chemical equation representing the removal of chemically bound water from blue vitriol is:

$$CuSO_4.5H_2O(s) \xrightarrow[\text{Conc.}H_2SO_4]{} CuSO_4(s) + 5H_2O(l).$$

(b) 1. The balanced chemical equation illustrating the strong dehydrating action on white cane sugar is:

$$C_{12}H_{22}O_{11}(s) \xrightarrow[\text{Conc.}H_2SO_4]{} 12C(s) + 11H_2O(l).$$

2. The rapid reaction produces a black, porous spongy mass as a new substance, which is chemically known as sugar charcoal.

163. Rohan is tasked with organizing the chemical storeroom at his school before the humid monsoon season begins. He finds an old bottle of washing soda crystals that was left completely unsealed on the top shelf. Upon inspection, he discovers that the once-clear crystals have completely crumbled into a fine white powder. On another shelf, he notices a container of pure sodium hydroxide pellets that have become entirely moist and dissolved into a puddle of liquid. He remembers his teacher explaining that different compounds interact with atmospheric moisture in completely opposite ways depending on the vapour pressure inside the crystals.

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Rohan carefully relabels the bottles with their specific chemical property terms to prevent future mishaps.

(a) Name the chemical phenomenon exhibited by the washing soda crystals when exposed to dry air.

(b) Write the balanced chemical equation for the change that occurs when washing soda is exposed to dry air.

(c) Name the chemical phenomenon exhibited by the sodium hydroxide pellets.

(d) State the condition under which the phenomenon exhibited by sodium hydroxide is minimized.

Ans :

(a) The chemical phenomenon exhibited by the washing soda crystals when they lose their water of crystallisation on exposure to dry air is called efflorescence.

(b) The balanced chemical equation for the formation of a monohydrate upon exposure to dry air is:

$$Na_2CO_3.10H_2O(s) \rightarrow Na_2CO_3.H_2O(s) + 9H_2O(l).$$

(c) The chemical phenomenon exhibited by the sodium hydroxide pellets, where they absorb atmospheric moisture and eventually dissolve to form a saturated solution, is called deliquescence.

(d) The phenomenon of deliquescence is minimised during dry conditions because the vapour pressure inside the crystals tends to be very low compared to the atmospheric air.

164. Anjali visits a coastal town during her winter vacation and immediately notices that the climate is much warmer than her inland hometown located at the exact same latitude. She also observes that despite the sub-zero temperatures in the nearby mountains, the deep lakes do not freeze completely or suddenly to the bottom. During a laboratory session after her trip, she accidentally exposes her hand to hot steam at 100°C. She finds that the steam causes a much more severe burn than the boiling water she was using earlier at the exact same temperature. She begins investigating the unique thermal and physical properties of water in her textbook to understand the scientific reasons behind these real-world phenomena.

(a) Name the physical property of water responsible for modifying the climate of the coastal town.

(b) State the numerical value of the specific heat capacity of water at 25°C with its correct unit.

(c) Name the thermal property due to which the lakes do not freeze suddenly.

(d) Give one reason why steam causes more severe burns than boiling water at 100°C.

Ans :

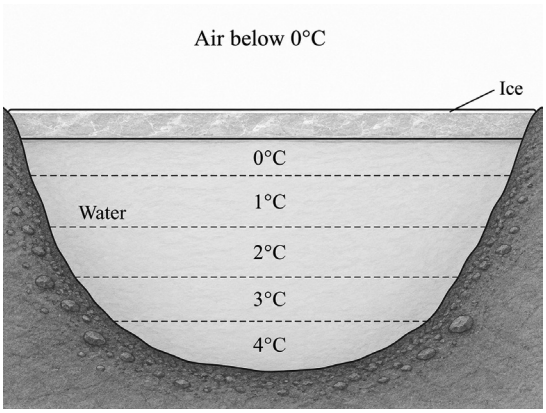
(a) Because of its very high specific heat capacity, the presence of a large amount of water can modify the climate of the nearby land areas.

(b) The amount of heat required to raise the temperature of one gram of water, known as specific heat capacity, is 4184 J kg^{-1} K^{-1} at 25°C.

(c) The thermal property responsible for preventing the sudden freezing of deep lakes during sub-zero winters is the high specific latent heat of solidification of ice.

(d) Steam causes much more severe burns than boiling water at 100°C because it releases an additional large amount of energy known as the latent heat of vapourisation.

165. Karthik is studying the unique thermal behaviour of liquids during extremely cold weather for his science fair project. He carefully examines an illustration provided by his teacher that explains how aquatic life survives in frozen lakes. The visual model depicts a cross-section of a natural water body during winter, detailing the temperature gradient from the surface to the bottom.



(a) State the unique physical property of water that is responsible for the temperature distribution shown in the diagram.

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(b) State what happens to the volume and density of water when it is cooled from 4°C to 0°C.

(c) Explain how the layer labelled "Ice" helps aquatic life survive in the liquid water below it, mentioning the densities involved.

Ans :

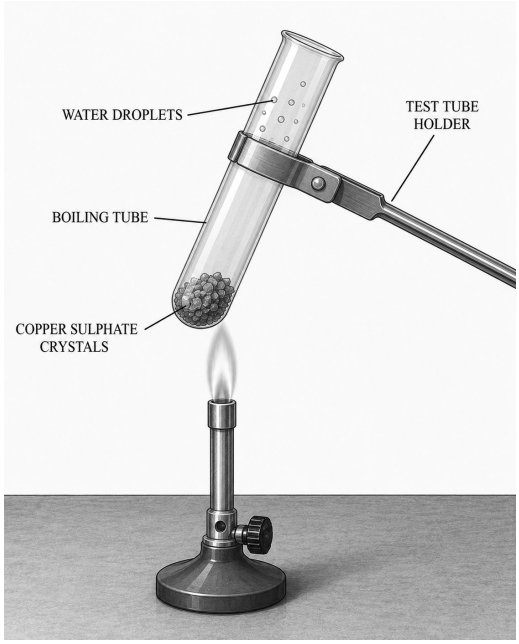
(a) The unique physical property of water responsible for this specific temperature distribution and the survival of marine life is the anomalous expansion of water.

(b) When water is cooled from 4°C down to 0°C, it undergoes anomalous expansion, meaning its total volume increases while its overall density simultaneously decreases.

(c) 1. The density of liquid water is greater than the density of solid ice, meaning the frozen ice layer naturally floats on the surface of the pond.

2. The solid ice layer acts as a bad conductor of heat, preventing the freezing cold external temperatures from further cooling the liquid water below it.

166. Priya is conducting a thermal decomposition experiment in her school laboratory to study hydrated substances. She places some blue-coloured crystalline solid into a glass tube and applies direct heat using a laboratory burner. The experimental setup is arranged exactly as depicted in the illustration below, allowing her to observe the condensation of vapours.



(a) State the colour change that occurs in the crystals left at the bottom of the tube after strong heating.

(b) Define the term 'water of crystallisation' based on the process shown.

(c) Write the balanced chemical equation with state symbols for the reaction occurring inside the heated tube, and state what happens if a few drops of water are added to the cooled residue.

Ans :

(a) When the hydrated blue-coloured copper sulphate crystals are strongly heated over the burner flame, they lose their water of crystallisation and turn completely white.

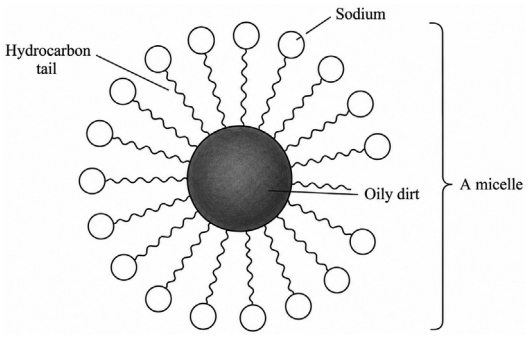
(b) Water of crystallisation is the definite quantity of water molecules that chemically combine with a solid and form an integral part of the structure of a crystal.

(c) 1. The balanced chemical equation for the thermal decomposition reaction occurring inside the boiling tube is:

$$CuSO_4.5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(l).$$

2. If a few drops of water are added to the cooled white anhydrous residue, it turns blue again due to the formation of hydrated copper sulphate.

167. Manoj is studying the mechanism by which synthetic detergents and household cleaning agents remove stubborn stains from fabrics. He refers to an illustration in his textbook that models the microscopic interaction between the cleaning molecules and a droplet of grease. He analyses the dual nature of the molecules to understand how they lift the dirt off the unclean surface.



(a) Explain the roles of the part labelled "Hydrocarbon tail" and the part labelled "Sodium" in the removal of the central droplet from a fabric.

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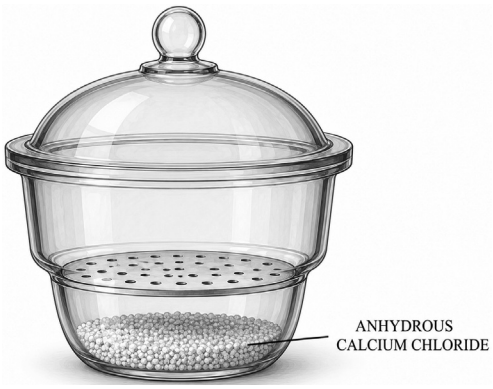
(b) Give one reason why synthetic detergents are considered more effective than soap for this cleaning action when the water supply contains dissolved calcium and magnesium sulphates.

Ans :

(a) 1. The long hydrocarbon tail actively clings to the oily dirt and debris during the cleaning process, allowing it to be lifted off the unclean fabric surface.
2. The negatively charged heads associated with sodium stay in the water and prevent the small separated oily globules from coming together and forming aggregates again.

(b) 1. Synthetic detergents are unaffected by the hardness of water because their resulting calcium and magnesium salts are completely soluble in the water.
2. Because these specific salts remain dissolved, the synthetic detergents do not form a useless white curdy precipitate or scum, thereby cleaning the clothes much more effectively.

168. Neha needs to dry some moist solid chemical samples over several days without applying any direct heat. She places the samples inside a specialized thick-walled glass container provided by her laboratory instructor, leaving them to sit undisturbed overnight. She relies on a specific chemical agent placed at the bottom of the container to absorb the ambient moisture.



(a) Identify the specific name of the airtight glass vessel shown in the diagram, and state the chemical term used to describe substances like anhydrous calcium chloride that absorb moisture without chemically reacting.

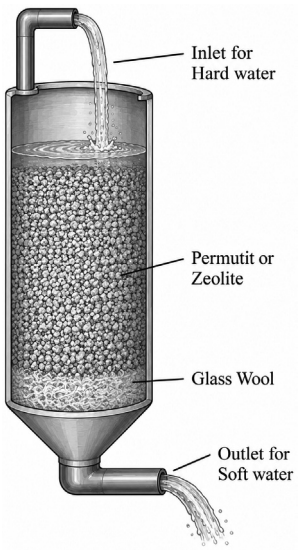
(b) Compare two specific differences between a drying agent and a dehydrating agent based on their chemical behaviour.

Ans :

(a) 1. The specific airtight glass vessel shown in the provided diagram, which is used to dry the materials placed inside it, is called a desiccator.
2. Chemicals like anhydrous calcium chloride that actively absorb moisture and excess water from other substances without chemically reacting with them are called drying agents.

(b) 1. Drying agents remove physical moisture from other substances, whereas dehydrating agents forcefully remove chemically combined elements of water in a precise ratio of hydrogen to oxygen.
2. The action of a drying agent represents a purely physical change, whereas the action of a dehydrating agent represents a chemical change where new substances form.

169. Vikram is visiting a large-scale municipal water softening plant to understand how permanent hardness is removed from groundwater. He examines the schematic diagram of a tall cylindrical reactor used continuously at the facility to treat large amounts of water. He takes notes on the specific materials used to exchange ions and completely soften the water.



(a) State the chemical name of the hydrated substance used as permutit in this process.

(b) State the general formula used for convenience to represent the sodium permutit.

(c) Name the two ions from the hard water that exchange with the sodium ions in the permutit lumps.

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(d) Name the naturally produced mineral found in large deposits of volcano tuff that is used for ion exchange.

Ans :

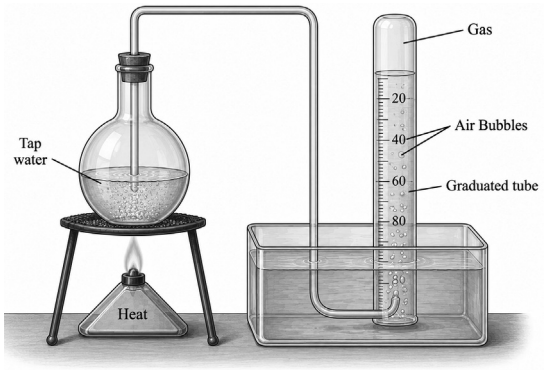
(a) The correct chemical name of the artificially hydrated substance used as permutit in this softening process is hydrated sodium aluminium orthosilicate.

(b) For the sake of scientific convenience and simplicity during chemical equations, the sodium permutit is generally represented by the specific formula Na_2P.

(c) During the ion exchange process, the positively charged calcium and magnesium ions present in the hard water exchange places with the sodium ions in the permutit.

(d) The naturally produced mineral found in abundance in large deposits of volcano tuff that is heavily used for ion exchange is known as zeolite.

170. Sunita is performing a laboratory demonstration to prove that ordinary tap water contains non-solid dissolved substances. She sets up the apparatus as shown in the diagram and gently heats the flask containing the water sample. She watches closely as the escaping bubbles displace the water inside the inverted collection tube.



(a) State the purpose of the inverted graduated tube in this experiment.

(b) Name the two main components of air dissolved in water.

(c) State the biological importance of the oxygen dissolved in water for aquatic life.

(d) State the effect of an increase in temperature on the solubility of a gas in water.

Ans :

(a) The inverted graduated tube is carefully placed over the delivery tube to collect the escaping gas bubbles through the downward displacement of the cold water.

(b) The two main components of atmospheric air that are commonly present in a dissolved state within all natural water sources are nitrogen and oxygen.

(c) Marine life, such as fish, actively utilise the oxygen of the air dissolved in the water for vital respiration processes, thereby sustaining all aquatic life.

(d) According to the physical properties of solutions, an increase in the overall temperature of the water causes a significant decrease in the solubility of a gas.

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CHAPTER 4

Atomic Structure and Chemical Bonding

SUMMARY

1. ATOM

An atom is the smallest particle of matter. The idea that atoms cannot be broken down further was first proposed by John Dalton. However, later discoveries proved that atoms are actually made up of even smaller particles.

1.1 Electron

Electrons were discovered by J.J. Thomson. This discovery showed that Dalton's idea of an "unbreakable" atom was not completely correct. Electrons are negatively charged particles and carry a unit negative charge (-1).

1.2 Proton

Protons were discovered by Goldstein. They are found inside the nucleus (center) of an atom. Protons are positively charged particles and carry a unit positive charge (+1).

1.3 Neutron

Neutrons were discovered by Chadwick. They are also present inside the nucleus. Neutrons carry no charge at all, meaning they are completely neutral.

Why is an Atom Neutral?

Even though an atom contains both positive and negative particles, it has no overall charge. This is because the number of protons always equals the number of electrons, so the charges cancel each other out — making the atom electrically neutral.

2. DISCOVERY OF NUCLEUS

The nucleus was discovered by Ernest Rutherford through his famous Alpha Scattering Experiment.

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The Alpha Scattering Experiment

Rutherford fired alpha particles, which carry a positive charge, at a very thin gold foil. He observed that most of the alpha particles passed straight through the foil without any deflection. However, some particles were deflected at large angles, and a very few bounced straight back.

Conclusions from the Experiment

From the above observations, Rutherford concluded that an atom is mostly empty space. He also concluded that all the positive charge and mass of an atom is concentrated in a very tiny central region called the nucleus.

Rutherford's Model of the Atom

Rutherford proposed that the nucleus is present at the centre of the atom and is very small in size. The nucleus contains positively charged particles known as nucleons. The electrons revolve around the nucleus at very high speeds and at varying distances from it.

Drawback of Rutherford's Model

Rutherford's model could not explain the stability of the atom. According to the Electromagnetic Theory, a charged particle moving in a circular path continuously loses energy and should gradually spiral inward and fall into the nucleus. However, atoms are perfectly stable in reality, which Rutherford's model failed to explain.

3. BOHR'S MODEL OF ATOM (STABILITY TO NUCLEUS)

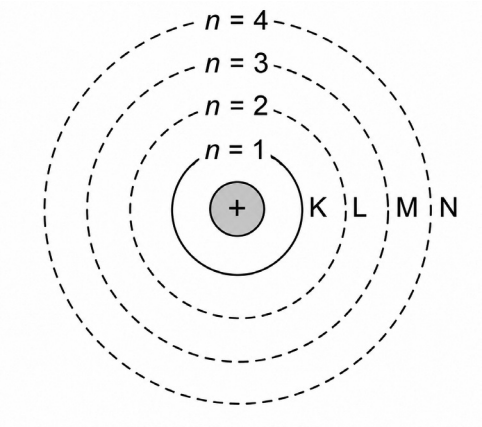
1. Bohr's model of atom could give the stability to the nucleus as Bohr suggested that at the centre of the atom, nucleus is present and outside the nucleus, in the fixed orbits, the electrons revolve around the nucleus.
2. As long as electron revolves in its certain fixed orbit, it will neither lose energy nor it will gain energy.
3. Orbits: The orbits are also called energy levels or shells as they are associated with the certain fixed amount of energy.

4. The shells or orbits or energy levels are numbered as 1, 2, 3, 4, ... or designated as K, L, M, N, ... respectively.
5. The electron cannot move in the space between the orbits as it is a forbidden area or territory.

4. QUANTA

Electrons absorb definite amount of energy in the form of quanta. Quanta are the packets of energy.

1. If the electron jumps from lower level to higher level, then it absorbs the energy in the form of quanta.
2. The energy of the electron increases as it moves away from the nucleus, i.e. the electron present in K-shell has the minimum energy and the electron present in N-shell has the maximum energy.



5. DISCOVERY OF NEUTRON

The mass of an atom is concentrated in its nucleus, while the electrons revolving around it have negligible mass. Therefore, the mass of an atom should simply be equal to the total mass of all the protons present inside the nucleus.

However, experiments revealed that the actual mass of an atom is far greater than the mass of its protons alone. This suggested that there must be some other particle present inside the nucleus that was contributing to the extra mass. Since this particle had no effect on the charge of the atom, it was concluded that it must be electrically neutral.

This neutral sub-atomic particle was later discovered by Chadwick and was named the neutron.

6. THE MODERN VIEW ABOUT THE STRUCTURE OF ATOM:

This view suggests:

(i) Inside the nucleus, protons and neutrons are present which are collectively called nucleons.
(ii) The electrons revolve around the nucleus in fixed orbits.
(iii) The mass of an atom is concentrated inside the nucleus of an atom.
(iv) An atom is electrically neutral because the number of protons is always equal to the number of electrons, causing their charges to cancel each other out.

7. CHARACTERISTICS OF ELECTRON PROTON AND NEUTRON:

(A) atom is made up of three fundamental sub-atomic particles — electron, proton and neutron. Each of these particles has its own distinct properties such as charge, mass and symbol. The following table summarizes the key characteristics of these particles.

Particle	Symbol	Charge	Mass (amu)	Property
Electron	e or $_{-1}^{0}e$	-1 or -1.602×10^{-19} C	$\frac{1}{1837}$ of mass of hydrogen atom	They possess a unit negative charge and has negligible mass.
Proton	p or $_{1}^{1}p$	$+1$ or $+1.602 \times 10^{-19}$ C	1 amu	They possess a unit positive charge and mass is nearly equal to that of hydrogen.
Neutron	n or $_{0}^{1}n$	nil	1 amu	These are electrically neutral particles and mass is almost equal to that of hydrogen.

7.1 Atomic Number

Atomic number is denoted by 'Z'. It is the number of protons present inside the nucleus of an atom. Atomic number is also equal to the number of electrons in the neutral atom.
Atomic number = Number of protons = Number of electrons.

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7.2 Mass Number

Mass number of an atom is denoted by 'A'. It is the sum of number of protons and number of neutrons present inside the nucleus of an atom.

Mass number

= Number of protons + Number of neutrons.

Number of neutrons

= Mass number – Atomic number.

7.3 Representation of an Element

Every element can be represented in a standard scientific notation that conveys both its mass number and atomic number at a glance. In an atom of an element, the superscript denotes the mass number and subscript denotes the atomic number.

$^{A}_{Z}X$ where, A = mass number

Z = atomic number

For example: $^{35}_{17}Cl$

Mass number	Atomic number	No. of electrons (e)	No. of protons (p)	No. of neutrons (n)
35	17	17	17	35 – 17 = 18

7.4 Mass of an Atom

Mass of An Atom is contributed by the number of protons and the number of neutrons present in the nucleus of an atom and the electrons outside the nucleus are of negligible mass.

8. BOHR – BURY SCHEME

The distribution of electrons in various energy levels is governed by Bohr – Bury scheme. According to this scheme, there are three important rules.

(i) Maximum number of electrons that can be accommodated in a shell is given by, $2n^2$ where n = number of shells or energy levels.

K-shell	$n = 1$	$2 \times 1 \times 1 = 2$
L-shell	$n = 2$	$2 \times 2 \times 2 = 8$
M-shell	$n = 3$	$2 \times 3 \times 3 = 18$
N-shell	$n = 4$	$2 \times 4 \times 4 = 32$

(ii) The outermost shell of an atom cannot have more than eight electrons, even though it may have the capacity to hold more and hence the penultimate shell, i.e. second last shell cannot have more than eighteen electrons.

(iii) The new shell begins as soon as the outermost shell attains 8 electrons.

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9. ELECTRONIC CONFIGURATIONS

The arrangement or the distribution of electrons in the various energy levels or shells is called electronic configuration.

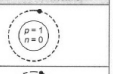
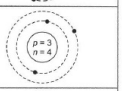
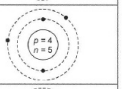
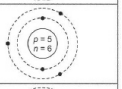
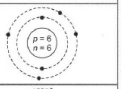
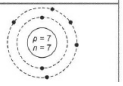
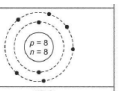
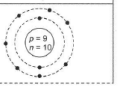
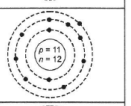
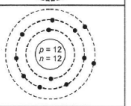
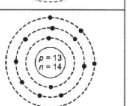
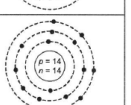
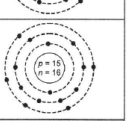
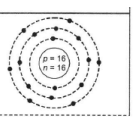
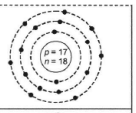
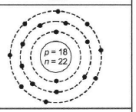
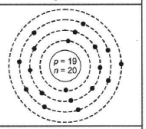
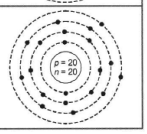
Electronic Configurations of the Elements from Atomic Number 1 to 20:

Elements	Symbols	Atomic number	Electronic configurations			
			K	L	M	N
Hydrogen	H	1	1			
Helium	He	2	2			
Lithium	Li	3	2	1		
Beryllium	Be	4	2	2		
Boron	B	5	2	3		
Carbon	C	6	2	4		
Nitrogen	N	7	2	5		
Oxygen	O	8	2	6		
Fluorine	F	9	2	7		
Neon	Ne	10	2	8		
Sodium	Na	11	2	8	1	
Magnesium	Mg	12	2	8	2	
Aluminium	Al	13	2	8	3	
Silicon	Si	14	2	8	4	
Phosphorus	P	15	2	8	5	
Sulphur	S	16	2	8	6	
Chlorine	Cl	17	2	8	7	
Argon	Ar	18	2	8	8	
Potassium	K	19	2	8	8	1
Calcium	Ca	20	2	8	8	2

This table shows an interesting property of atoms. We see that neon has 2 electrons in the first (K) shell and 8 electrons in the second (L) shell. Similarly, argon has 2 electrons in the first (K) shell, 8 electrons in the second (L) shell and 8 electrons in the third (M) shell. Neon and argon have completely filled outermost shells.

10. GEOMETRICAL REPRESENTATION

Geometrical representation of atomic structure of elements from atomic number 1 to 20:

Elements	*Mass numbers*	*Atomic numbers*	*Protons*	*Electrons*	*Neutrons*	*Geometrical representation of atomic structure*
Hydrogen $^{1}_{1}H$	1	1	1	1	1 – 1 = 0	
Helium $^{4}_{2}He$	4	2	2	2	4 – 2 = 2	
Lithium $^{7}_{3}Li$	7	3	3	3	7 – 3 = 4	
Beryllium $^{9}_{4}Be$	9	4	4	4	9 – 4 = 5	
Boron $^{11}_{5}B$	11	5	5	5	11 – 5 = 6	
Carbon $^{12}_{6}C$	12	6	6	6	12 – 6 = 6	
Nitrogen $^{14}_{7}N$	14	7	7	7	14 – 7 = 7	
Oxygen $^{16}_{8}O$	16	8	8	8	16 – 8 = 8	
Fluorine $^{19}_{9}F$	19	9	9	9	19 – 9 = 10	
Neon $^{20}_{10}Ne$	20	10	10	10	20 – 10 = 10	
Sodium $^{23}_{11}Na$	23	11	11	11	23 – 11 = 12	
Magnesium $^{24}_{12}Mg$	24	12	12	12	24 – 12 = 12	
Aluminium $^{27}_{13}Al$	27	13	13	13	27 – 13 = 14	
Silicon $^{28}_{14}Si$	28	14	14	14	28 – 14 = 14	
Phosphorus $^{31}_{15}P$	31	15	15	15	31 – 15 = 16	
Sulphur $^{32}_{16}S$	32	16	16	16	32 – 16 = 16	
Chlorine $^{35}_{17}Cl$	35	17	17	17	35 – 17 = 18	
Argon $^{40}_{18}Ar$	40	18	18	18	40 – 18 = 22	
Potassium $^{39}_{19}K$	39	19	19	19	39 – 19 = 20	
Calcium $^{40}_{20}Ca$	40	20	20	20	40 – 20 = 20	

11. VALENCE ELECTRONS:

The number of electrons present in the outermost shell of an atom are called the valence electrons. In chemical reactions, only the valence electrons are involved, i.e. only the valence electrons are shared and transferred. Each and every atom tries to attain the configuration of the nearest inert gas, i.e. having eight electrons in its valence shell, having stable configuration following the octet rule. Elements having same number of valence electrons exhibit same chemical properties.

1. Metals have 1, 2 or 3 electrons in their valence shell or outermost shell. To attain stable configuration
   (i.e. eight electrons in the outermost shell), they easily lose electrons and get converted into positively charged particles called cations. Hence metals are good reducing agents, i.e. electron donors.
   For example:
   Sodium :
   $$Na - e^- \longrightarrow Na^+$$
   2, 8, 1 2, 8
   Magnesium :
   $$Mg - 2e^- \longrightarrow Mg^{2+}$$
   2, 8, 2 .....2, 8
   Aluminium :
   $$Al - 3e^- \longrightarrow Al^{3+}$$
   2, 8, 3 .....2, 8
2. Non-metals have 5, 6 or 7 electrons in their outermost shell or valence shell. To attain stable configuration (i.e. eight electrons in their outermost shell), they easily gain

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electrons and get converted to negatively charged particles called anions. Hence non-metals are good oxidizing agents, i.e. electron acceptors.
For example:
Phosphorus :

$$P + 3e^- \longrightarrow P^{3-}$$

2, 8, 5 2, 8, 8

Sulphur : $S + 2e^- \longrightarrow S^{2-}$

2, 8, 6.....2, 8, 8

Chlorine : $Cl + e^- \longrightarrow Cl^-$

2, 8, 7.....2, 8, 8

12. NOBLE GASES (INERT GASES):

Elements having eight electrons in their outermost shell or valence shell are chemically inactive and they fall under the category of inert gases or noble gases. Except helium, all the inert gases like neon, argon, krypton, xenon and radon have eight electrons in their valence shell, whereas helium has only two electrons in its K-shell.

13. ISOTOPES

Isotopes of an element are the atoms of same element having same atomic number but different mass number.
For example:
Hydrogen has three isotopes,
Carbon has three isotopes,
Chlorine has two isotopes.

Isotopes of hydrogen

Isotopes		Mass no.	Atomic no.	Protons	Electrons	Neutrons
Name	Symbol					
(i) Protium	$^{1}_{1}H$	1	1	1	1	0
(ii) Deuterium	$^{2}_{1}H$	2	1	1	1	1
(iii) Tritium	$^{3}_{1}H$	3	1	1	1	2

Isotopes of carbon

Symbol	Mass no.	Atomic no.	Protons	Electrons	Neutrons
$^{12}_{6}C$	12	6	6	6	6
$^{13}_{6}C$	13	6	6	6	7
$^{14}_{6}C$	14	6	6	6	8

Isotopes of chlorine

Symbol	Mass no.	Atomic no.	Protons	Electrons	Neutrons
$^{35}_{17}C$	35	17	17	17	18
$^{37}_{17}C$	37	17	17	17	20

This shows that isotopes have different number of neutrons.

1. Isotopes have the same chemical properties as they have the same atomic number.
2. Isotopes have same number of valence electrons as their atomic number is same.
3. Isotopes have different physical properties as their mass number is different.
4. Causes of Fractional Atomic Masses of the Elements: Fractional atomic masses of the elements are because of the presence of Isotopes.

For example: Natural chlorine has two isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$ in the ratio of 3 : 1.
So, the atomic mass can be calculated as follows:
Atomic mass of 3 atoms of

$$^{35}_{17}Cl = 3 \times 35 = 105 \text{ amu.}$$

Atomic mass of 1 atom of

$$^{37}_{17}Cl = 1 \times 37 = 37 \text{ amu.}$$

Average atomic mass of chlorine

$$= \frac{3 \times 35 + 1 \times 37}{4} = \frac{105 + 37}{4}$$

$$= \frac{142}{4} = 35.5 \text{ amu}$$

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14. CHEMICAL BONDING

The chemical bond is the force of attraction which holds the different or the same particles together in a molecule.

14.1 Why Do Atoms Form Chemical Bonds?

The chemical bonding results in the decrease of the energy of the participating elements and thus acquiring a comparatively stable state in a molecule than the participating elements. For example, a molecule of hydrogen(H_2) is more stable than the two atoms of hydrogen as the energy of hydrogen molecule is less than the individual hydrogen atoms.

14.2 Electrical Neutrality of an Atom

An atom is electrically neutral. The number of positively charged particles (i.e. protons) is equal to the number of negatively charged particles (i.e. electrons).

14.3 Octet Rule

While undergoing chemical bond formation, each and every atom tries to attain the valence configuration of nearest inert gas, i.e. having eight electrons in their valence shell following octet rule.

The outermost octet can be achieved by the following two ways:

(i) By the transference of electrons, i.e. by losing electrons from the outermost shell or by gaining electrons in the outermost shell.

(ii) By the mutual sharing of electrons.

14.4 Classification of Chemical Bonds

On the basis of the above two categories, the chemical bonds are classified as follows:

(i) By the transfer of electrons: Ionic or Electrovalent bond.

(ii) By the mutual sharing of electrons: Covalent bond.

14.5 Ion

When an atom loses or gains electron(s), it gets converted to electrically charged particle called an ion

14.6 Cation

When an atom loses electron, it gets converted to positively charged particle called cation.

14.7 Anion

When an atom gains electron, it gets converted to negatively charged particle called anion.

14.8 Electropositive elements:

The elements which easily lose electrons and acquire positive charge are called electropositive elements. Metals are electropositive elements. For example,

Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, etc.

14.9 Electronegative elements:

The elements which easily gain electrons and acquire negative charge are called electronegative elements. Non-metals are electronegative elements. For Example,

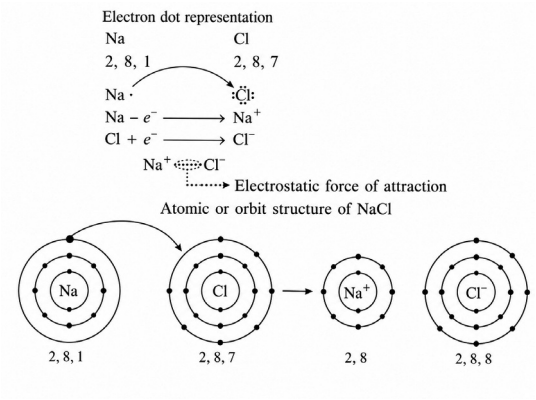
Cl^-, Br^-, I^-, F^-, O^{2-}, S^{2-}, N^{3-}, etc.

14.10 Electrovalent or Ionic bond:

The bond formed as a result of transfer of electrons from the outermost shell of a metal to the outermost shell of a non-metal is called an ionic bond or electrovalent bond.

Ionic bonds are formed between metals and non-metals. Metals lose electrons and non-metals gain electrons.

Electron dot representation



15. ELECTROVALENCY:

The number of electrons lost or gained by an atom of the element to acquire stable configuration in the formation of ionic bond is called electrovalency.

As a result of transfer of electron(s), ions are formed which are held by strong electrostatic force of attraction.

1. The metals participating in an ionic bond formation should have low ionisation potential.
2. The non-metals participating in an ionic bond formation should have high electron affinity.
3. The chemical compounds formed as a result of the transfer of electrons from the outermost shell of a metal to the outermost shell of non-metal are called ionic or electrovalent compounds.
4. The compounds formed by the transference of electrons are called Ionic or electrovalent compounds.

16. COVALENT BOND:

The bond formed as a result of mutual sharing of electrons of same or different elements is called covalent bond.

There are three types of covalent bond. They are single covalent bond, double covalent bond and triple covalent bond:

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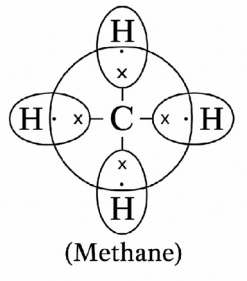
16.1 Covalency

The number of electrons shared during the formation of covalent bond is called covalency.
The covalent bond formation takes place between two non-metallic elements.
When the same or different non-metallic atoms present in groups 14, 15, 16 and 17 of periodic table combine together, covalent bonds are formed.
Both the atoms participating in covalent bond formation should have high electronegativity, high ionisation energy and high electron affinity.
During covalent bond formation, ions are not formed, only molecules are formed.

16.2 Non-polar covalent compounds:

The covalent compounds in which the combining elements have no or very slight difference in their electronegativities are called non-polar covalent compounds.



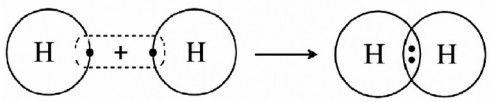
(Methane)

Example: H_2, Cl_2, N_2, O_2.
All hydrocarbons are non-polar covalent compounds, e.g. methane (CH_4), ethane (C_2H_6), ethene (C_2H_4), ethyne (C_2H_2) and carbon tetrachloride (CCl_4).

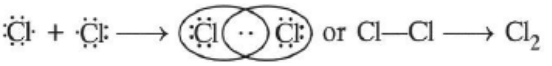
(i) A single covalent bond is formed by the sharing of one pair of electrons between atoms, each of which contributes only one electron. It is denoted by putting a single short line (—) between the two atoms.

(a) Formation of hydrogen molecule (H = 1)

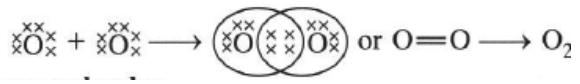
Orbit structure of hydrogen



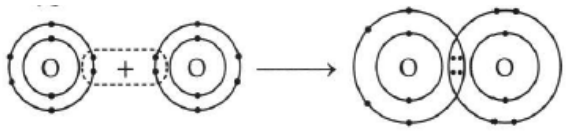
(b) Formation of chlorine molecule (Cl = 2, 8, 7)



(ii) A double covalent bond is formed by the sharing of two pairs of electrons between the two atoms each of which contributes two electrons. A double covalent bond is denoted by putting two short lines (=) between the two atoms.
Example: Formation of oxygen molecule (O = 2, 6)

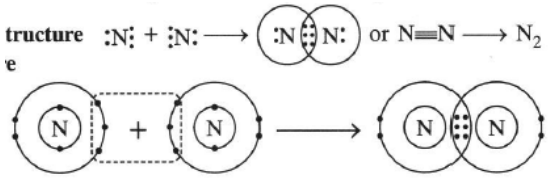


Orbit structure of oxygen molecules:



(iii) A triple covalent bond is formed by the sharing of three pairs of electrons between the two atoms each of which contributes three electrons. A triple covalent bond is denoted by putting three short lines (≡) between the two atoms.
Example: Formation of nitrogen molecule (N = 2, 5)

Electron dot structure Orbit structure



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17. POLAR COVALENT COMPOUNDS:

The covalent compounds in which the combining elements have comparatively large difference in their electronegativities are called polar covalent compounds.
Example: Hydrogen chloride gas (HCl), water (H_2O) and ammonia (NH_3).

1. The structures of a few electrovalent compounds are given below:

(i) Magnesium chloride

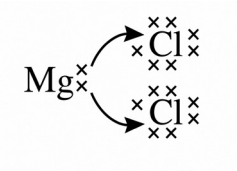
Mg = 2, 8, 2

Cl = 2, 8, 7

$$Mg - 2e^- \longrightarrow Mg^{2+}$$

$$2Cl + 2e^- \longrightarrow 2Cl^-$$

$$Mg^{2+} + 2Cl^- \longrightarrow MgCl_2$$



(ii) Calcium oxide

$$Ca = 2, 8, 8, 2$$

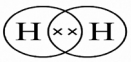
$$O = 2, 6$$

$$Ca - 2e^- \longrightarrow Ca^{2+}$$

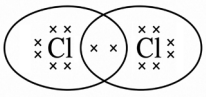
$$O + 2e^- \longrightarrow O^{2-}$$

$$Ca^{2+} + O^{2-} \longrightarrow CaO$$

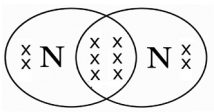
2. The structures of a few covalent molecules are given below.

(i) Hydrogen (H_2)  or H – H

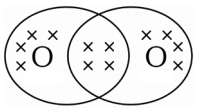
A single covalent bond is formed between two hydrogen atoms to form a hydrogen molecule.

(ii) Chlorine (Cl_2)  or Cl – Cl

A single covalent bond is formed between two chlorine atoms to form a chlorine molecule.

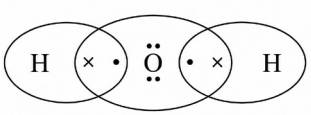
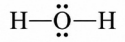
(iii) Nitrogen (N_2)  or

A triple covalent bond is formed between two nitrogen atoms to form a nitrogen molecule.

(iv) Oxygen (O_2)  or O = O

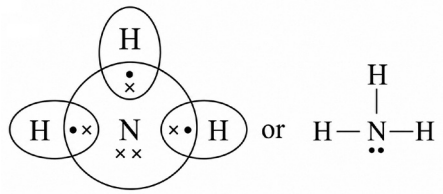
A double covalent bond is formed between two oxygen atoms to form an oxygen molecule.

(v) Water (H_2O)

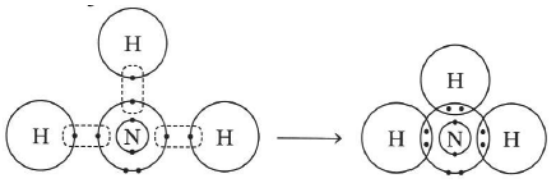
 or 

Oxygen atom has electronic configuration 2, 6. It has six electrons in its valence shell and achieves octet by sharing two electrons, one each with hydrogen atom.

(vi) Ammonia (NH_3)

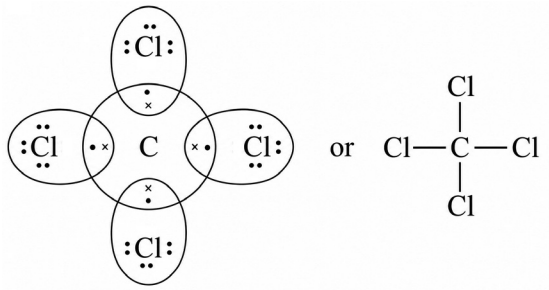


Orbit structure of NH_3



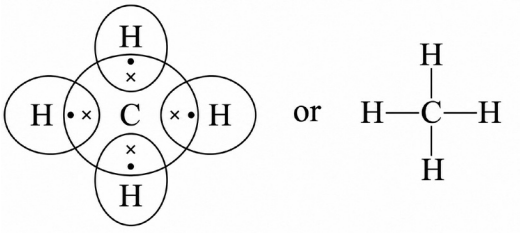
Nitrogen atom have five electrons in its valence shell and can achieve octet (stable configuration) by sharing three electrons, one each with three hydrogen atoms.

(vii) Carbon tetrachloride (CCl_4)



Carbon has four valence electrons. It can achieve octet by sharing four electrons one each with four chlorine atoms.

(viii) Methane (CH_4)



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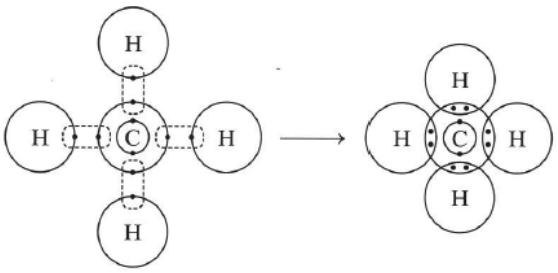
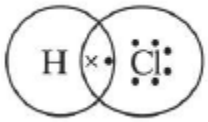
17.1 Atomic orbit structure

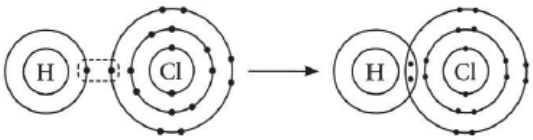


Carbon atom has four electrons in its valence shell. In order to complete its octet, it shares four electrons, one each with four hydrogen atoms.

(ix) Hydrogen chloride (HCl)



17.2 Orbit structure



Chlorine has 7 electrons in its valence shell, therefore, to complete its octet, it shares one electron with hydrogen atom.

A pair of electrons which does not take part in bond formation is called lone pair of electrons.

OBJECTIVE QUESTIONS

1. The earliest concept that matter is composed of discrete, indivisible units was provided by an ancient Indian philosopher. What name did he give to this smallest unit of matter?

(A) Atomos
(B) Paramanu
(C) Molecule
(D) Nucleon

Ans : (B)

Maharishi Kanada, an ancient Indian philosopher, conceptualised that matter is composed of discrete, indivisible units. He termed the smallest indivisible particle of matter as paramanu. The modern term atom was later coined by the Greek philosopher Democritus around 450 BC.

2. Read the following statements regarding Dalton's atomic theory and select the correct combination.

I. All forms of matter consist of very small and indivisible particles called atoms.
II. Atoms can be created and destroyed during a chemical process.
III. Atoms of a particular element are identical in mass, size, and chemical properties.
IV. Atoms of elements always combine in fractional ratios to form compound atoms.

(A) I and II only
(B) I and III only
(C) II and IV only
(D) III and IV only

Ans : (B)

John Dalton proposed his atomic theory in 1808 based on the laws of chemical combination. His fundamental postulates clearly stated that atoms are entirely indivisible, absolutely cannot be created or destroyed, and must combine strictly in simple whole-number mathematical ratios.

3. Rutherford's alpha-particle scattering experiment produced several key observations. Which observation from the table led to the conclusion that most of the space inside an atom is empty?

Observation ID	Experimental Result
1	Most α-particles passed through the gold foil undeviated.
2	Some α-particles were deflected by small angles.
3	A very few α-particles (1 in 20,000) completely rebounded.

(A) Observation 1
(B) Observation 2
(C) Observation 3
(D) Both Observation 2 and 3

Ans : (A)

Observation 1, which states that most alpha-particles passed straight through the foil, provided the evidence that most of an atom is empty space. If the atom were dense throughout, as suggested by Thomson's model, most particles would have been deflected. Observations 2 and 3 relate to the existence of a dense, positive nucleus.

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4. During the study of electric current conduction through gases, a coloured glow is observed inside the discharge tube. Under which specific pressure condition does this glow disappear while current continues to flow, producing faint greenish light?
(A) 1 atm
(B) 10-1 atm
(C) 10-2 atm
(D) 10-4 atm

Ans : (D)

When the gas pressure is further reduced to approximately 0.0001 atm inside the sealed discharge tube, the visible glow between the metallic electrodes completely disappears. However, electric current continues flowing steadily, and the tube inherently glows with faint greenish light.

5. The results of passing cathode rays and anode rays through an electric field are summarised in the table below. Based on the data, what conclusion can be drawn about their nature?

Ray Type	**Deflection Towards Positive Plate**	**Deflection Towards Negative Plate**
Cathode Rays	Yes	No
Anode Rays	No	Yes

(A) Both ray types are composed of positively charged particles.
(B) Both ray types are composed of negatively charged particles.
(C) Cathode rays are negatively charged, while anode rays are positively charged.
(D) Cathode rays are positively charged, while anode rays are negatively charged.

Ans : (C)

The table shows that cathode rays are deflected towards the positive plate, indicating they consist of negatively charged particles (electrons). Conversely, anode rays are deflected towards the negative plate, proving they consist of positively charged particles (protons or positive gaseous ions). This demonstrates the opposite nature of their electrical charges.

6. **Assertion (A) :** When a small paddle wheel is placed in the path of cathode rays, the paddle-wheel starts mechanical motion.
Reason (R) : Cathode rays travel in a straight line and cast shadows of objects placed in their path.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (B)

Both the assertion and the reason represent entirely correct experimental observations regarding cathode rays. However, the specific mechanical motion of the inserted paddle wheel practically occurs because cathode rays consist of actual material particles, not merely because they travel straight.

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7. R.A. Millikan successfully determined the absolute charge of an electron. Which of the following values correctly represents the negative charge on an electron in coulombs?

(A) 9.11×10^{-31}

(B) 1.67×10^{-24}

(C) 1.6022×10^{-19}

(D) 1.7588×10^{11}

Ans : (C)

R.A. Millikan precisely determined the absolute charge on a single electron to be exactly 1.6022×10^{-19} coulomb. This specific numerical value officially represents the smallest measurable quantity of electrical charge, thereby establishing the universally recognized unit electrical charge standard.

8. Identify the correct statement regarding the mass of an electron based on Thomson's calculations.
(A) It is exactly equal to the mass of a hydrogen atom.
(B) It is approximately 1/1840 times the mass of a hydrogen atom.
(C) It is exceptionally heavier than the mass of a standard proton.
(D) It varies significantly depending strictly on the discharge tube gas.

Ans : (B)

The meticulously calculated mass of a single electron equals approximately 9.11×10^{-31} kilograms. This specific mass remains negligibly small, being roughly 1/1840 times the standard mass of one hydrogen atom, confirming electrons as the lightest fundamental atomic constituent particles.

9. Read the following statements regarding anode rays and select the incorrect statement.
(A) Anode rays travel in a straight line.
(B) They are deflected by electric fields in the same direction as cathode rays.
(C) They consist of positively charged material particles.
(D) Their charge-to-mass ratio depends upon the nature of the gas taken.

Ans : (B)

Anode rays inevitably consist of positively charged material particles. Consequently, they firmly experience physical deflection across electric and magnetic fields in a distinctly opposite direction compared to the negatively charged cathode rays, proving their fundamentally opposite intrinsic electrical charge characteristics.

10. The charge-to-mass ratio (e/m) of positively charged particles in a discharge tube reaches its maximum value under a specific experimental condition. Which gas produces this maximum ratio?
(A) Helium
(B) Oxygen
(C) Nitrogen
(D) Hydrogen

Ans : (D)

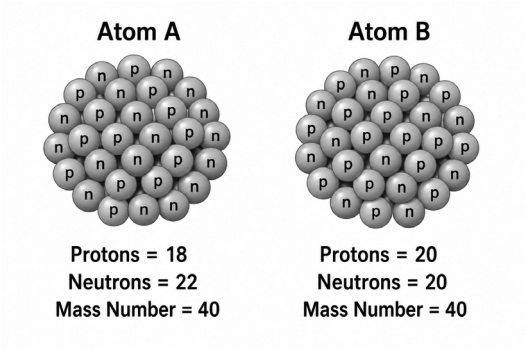
The charge-to-mass ratio of positively charged anode rays heavily depends upon the specific nature of the experimental gas enclosed. This physical ratio naturally achieves its absolute maximum mathematical value only when hydrogen gas uniquely occupies the sealed experimental discharge tube.

11. **Assertion (A) :** The total mass of all protons and electrons in an atom does not accurately account for the complete mass of the atom.
Reason (R) : The atomic nucleus inherently contains neutral subatomic particles called neutrons, which possess a mass nearly equal to a proton.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Rutherford perceptively noticed that protons and electrons alone simply could not explain total atomic mass. This crucial discrepancy was perfectly resolved by James Chadwick, who brilliantly discovered electrically neutral neutrons residing inside the nucleus, fully explaining the missing atomic mass.

12. The two nuclei depicted in the diagram are related. What term best describes this pair of atomic nuclei?



(A) Isotopes
(B) Isomers
(C) Isobars
(D) Allotropes

Ans : (C)

Isobars are atoms of different elements that have the same mass number (A) but different atomic numbers (Z). Atom A (Argon) has atomic number 18, and Atom B (Calcium) has atomic number 20. However, both have a mass number of 40 (protons + neutrons), making them a pair of isobars.

13. Match the subatomic particles in List-I with their respective discoverers in List-II.
List-I
P. Electron
Q. Proton
R. Neutron
S. Nucleus
List-II
I. Ernest Rutherford
II. J.J. Thomson
III. James Chadwick
IV. E. Goldstein
(A) P-II, Q-IV, R-III, S-I
(B) P-IV, Q-II, R-I, S-III
(C) P-II, Q-I, R-IV, S-III
(D) P-I, Q-IV, R-II, S-III

Ans : (A)

J.J. Thomson successfully discovered the negatively charged electron. E. Goldstein definitively identified the positively charged proton through canal rays. James Chadwick

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famously discovered the neutral neutron, whereas Ernest Rutherford conclusively discovered the extraordinarily dense central nucleus during alpha scattering experiments.

14. The Bohr-Bury scheme describes how electrons are distributed in shells. According to the rules, which row correctly represents the electronic configuration of a neutral Calcium atom (Z=20)?

Option	K-shell (n=1)	L-shell (n=2)	M-shell (n=3)	N-shell (n=4)
(A)	2	8	10	0
(B)	2	8	8	2
(C)	2	8	9	1
(D)	2	10	8	0

(A) Option A
(B) Option B
(C) Option C
(D) Option D

Ans : (B)

For Calcium (Z=20), the first shell (K) holds 2 electrons, and the second shell (L) holds 8. The third shell (M) can hold up to 18, but the outermost shell cannot have more than 8 electrons once filling begins. Thus, the M-shell takes 8 electrons, and the remaining 2 go into the N-shell, giving the configuration 2, 8, 8, 2.

15. Which conceptual component of Thomson's atomic model specifically resembles the edible red portion of a watermelon?
(A) The discrete negatively charged electrons
(B) The uncharged, massive central neutrons
(C) The uniform sphere of positive electricity
(D) The dense, centrally located atomic nucleus

Ans : (C)

J.J. Thomson cleverly proposed that an individual atom physically resembles a uniform sphere of positive electricity. In his popular watermelon model analogy, this distinct continuous positive sphere is explicitly represented by the widely distributed, soft edible red portion of the fruit.

16. During his legendary alpha-ray scattering experiment, Ernest Rutherford purposely selected a highly specific metallic substance to create an exceedingly thin foil. Which fundamental property motivated this strict material selection?
(A) Exceptional electrical conductivity
(B) Outstanding thermal insulation
(C) Extreme physical malleability
(D) Unusually low melting point

Ans : (C)

Ernest Rutherford specifically selected solid gold for his historic alpha-particle scattering experiment fundamentally because of its incredibly exceptional malleability. This unique metallic property practically allowed him to carefully hammer the material into an astonishingly thin foil measuring roughly 0.00006 cm.

17. Based strictly on the empirical observations collected during Rutherford's alpha-ray scattering experiment, what direct conclusion explained why incredibly few particles traversed back along their original path?
(A) The atomic mass is uniformly distributed.
(B) The entire atomic space remains practically empty.
(C) The heavy positively charged body inside is extremely small.
(D) The revolving electrons possess negligible mass.

Ans : (C)

Rutherford astutely observed that only roughly one alpha particle in twenty thousand bounced backward. This extremely rare deflection strongly proved that the enormously heavy, distinctly rigid, and positively charged central atomic body must occupy an incredibly tiny volumetric interior space.

18. **Assertion (A) :** Rutherford's planetary atomic model completely failed to logically explain the structural stability of an atom.
Reason (R) : According to classical electrodynamics, an electrically charged electron continuously radiating energy while moving would steadily spiral into the massive nucleus.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Rutherford's atomic model fundamentally contradicted classical electrodynamics. An accelerating charged electron ought to continuously lose its kinetic energy through radiation, eventually spiralling progressively inward and destructively colliding with the central positive nucleus, effectively rendering the theoretical atomic structure completely unstable.

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19. Niels Bohr fundamentally resolved atomic instability by introducing a ground breaking structural concept regarding electron movement. Which of the following best describes this crucial concept?

(A) Electrons drift randomly through a uniform positive sphere.
(B) Electrons remain strictly stationary within the dense atomic nucleus.
(C) Electrons orbit the nucleus exclusively in discrete allowed circular paths.
(D) Electrons completely share an equal electrostatic charge with the central nucleus.

Ans : (C)

Niels Bohr brilliantly solved the critical stability problem by strictly proposing that electrons revolve entirely within specific allowed circular orbits. While steadily moving within these designated discrete energy levels, the orbiting electron absolutely does not radiate any measurable kinetic energy.

20. The table describes the composition of the nuclei of four atomic species. Which pair of species represents isotopes?

Species	Number of Protons (Z)	Number of Neutrons
P	6	6
Q	7	7
R	6	8
S	8	8

(A) P and Q
(B) Q and R
(C) P and R
(D) R and S

Ans :(C)

Isotopes are atoms of the same element, meaning they must have the same number of protons (same atomic number, Z) but different numbers of neutrons. In the table, both species P and R have 6 protons, identifying them as the same element (Carbon). However, they have different numbers of neutrons (6 and 8 respectively), making them isotopes.

21. The atomic number of a neutral element intrinsically represents a fundamental property of the atom. Which specific combination of subatomic particles strictly equals the atomic number in a perfectly neutral atom?

(A) Number of protons only
(B) Total number of protons and neutrons
(C) Number of protons or number of electrons
(D) Total number of nucleons and valence electrons

Ans : (C)

The strictly defined atomic number explicitly signifies the exact count of unit positive charges, meaning individual protons, securely residing within the central nucleus. Since a neutral atom remains electrically balanced, this number simultaneously equals the total count of orbiting electrons.

22. An element features precisely 15 protons securely residing within its atomic nucleus alongside 16 neutrons. What are the correct numerical values for its atomic number (Z) and mass number (A)?

(A) Z = 16, A = 31
(B) Z = 15, A = 31
(C) Z = 31, A = 15
(D) Z = 15, A = 16

Ans : (B)

The defined atomic number perfectly matches the exact proton count, which confidently equals 15. The designated mass number mathematically reflects the straightforward algebraic sum of the resident protons and neutral neutrons combined, calculating precisely to 31 for this specific element.

23. Consider the following elementary particle data. Read the statements and select the correct combination regarding elementary properties.

I. The absolute mass of a proton is mathematically $1.67 \times 10^{-24} g$.
II. The relative electrical charge on an electron is considered zero.
III. The absolute charge on a neutral neutron is naturally exactly zero.
IV. A proton possesses a negative absolute charge of 1.6×10^{-19}C.

(A) I and II only
(B) I and III only
(C) II and IV only
(D) III and IV only

Ans : (B)

A proton intrinsically features a strictly positive relative charge combined with an exact absolute mass of roughly 1.67×10^{-24} grams. A typical electron distinctly carries a relative negative charge, whereas a fundamental neutron predictably holds absolutely zero electrical charge.

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24. According to the independent theoretical rules clearly proposed by Bohr and Bury, what is the maximum number of electrons that can be physically accommodated within the M-shell (third shell) of an atom?
(A) 2
(B) 8
(C) 18
(D) 32

Ans : (C)

The Bohr-Bury electronic distribution framework rigorously limits any given atomic shell's maximum electron capacity using the $2n^2$ mathematical formula. Since the M-shell accurately corresponds to the third energy level (n = 3), it logically accommodates exactly eighteen valence electrons altogether.

25. The table below provides information about four neutral atoms. Using the relationships between atomic number (Z), mass number (A), protons, neutrons, and electrons, identify the element that is an atom of Sodium (Na).

Element	Number of Protons (Z)	Number of Neutrons	Number of Electrons
W	12	12	12
X	11	12	11
Y	17	18	17
Z	11	11	12

(A) Element W
(B) Element X
(C) Element Y
(D) Element Z

Ans : (B)

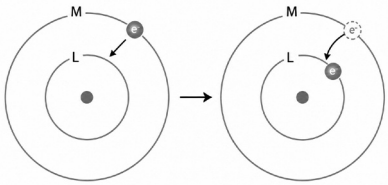
The atomic number (Z) of Sodium (Na) is 11, which equals the number of protons. In a neutral atom, the number of electrons must equal the number of protons. Element X is the only option with 11 protons and 11 electrons. The most common isotope of sodium has a mass number of 23 (11 protons + 12 neutrons).

26. **Assertion (A) :** The third shell of calcium (Ca) contains exactly 8 electrons, even though it possesses a maximum capacity to hold 18 electrons.
Reason (R) : The outermost atomic shell fundamentally cannot mathematically hold more than 8 stable electrons according to the Bohr-Bury scheme.
(A) Both A and R are true and R is the correct of A.
(B) Both A and R are true but R is not the correct of A.
(C) A is true but R is false.
(D) A is false but R is true.

Ans : (A)

Although the third atomic shell mathematically supports up to eighteen electrons, stability rules firmly restrict the outermost shell to exactly eight. Consequently, the calcium atom safely fills its third shell with eight electrons before steadily populating its subsequent fourth shell.

27. The diagram shows an electron transition between two energy shells, L and M. What is the energetic consequence of the process shown by the arrow?



(A) Energy is absorbed in the form of a photon.
(B) Energy is emitted in the form of a photon.
(C) There is no change in the electron's energy.
(D) The nucleus absorbs the energy difference.

Ans : (B)

According to Bohr's model, electrons in outer shells have higher energy than those in inner shells. When an electron transitions from a higher energy level (M shell) to a lower energy level (L shell), the excess energy is released. This release occurs as a discrete packet of electromagnetic radiation, known as a photon.

28. Carefully analyse the electronic configuration of a standard phosphorus atom possessing an atomic number precisely equal to 15. What is the correct stepwise distribution of these 15 electrons?
(A) 2, 8, 5
(B) 2, 5, 8
(C) 8, 2, 5
(D) 2, 8, 4, 1

Ans : (A)

A neutral phosphorus atom naturally features fifteen individual orbiting electrons. Strictly following the Bohr-Bury stepwise filling principles, the initial K-shell securely holds two electrons,

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the subsequent L-shell fully accommodates eight, leaving exactly five electrons remaining exclusively within the outermost M-shell.

29. Identify the fundamental chemical element whose designated atomic nucleus uniquely contains absolutely no neutrons in its naturally stable primary form.
(A) Helium
(B) Carbon
(C) Hydrogen
(D) Oxygen

Ans : (C)

The lightest recognized isotope of hydrogen, specifically known as protium, naturally stands as the sole chemical element possessing a unique atomic nucleus completely lacking neutrons. This profoundly simple nucleus strictly consists of precisely one positively charged proton functioning entirely alone.

30. The chemical reactivity of an element is determined by its valence electrons. The table shows four elements and their electronic configurations. Which element is most likely to form a divalent cation (ion with a +2 charge)?

Element	**Atomic Number (Z)**	**Electronic Configuration**
Lithium (Li)	3	2, 1
Magnesium (Mg)	12	2, 8, 2
Aluminium (Al)	13	2, 8, 3
Phosphorus (P)	15	2, 8, 5

(A) Lithium
(B) Magnesium
(C) Aluminium
(D) Phosphorus

Ans : (B)

A divalent cation (+2 charge) is formed when a neutral atom loses two valence electrons. According to the table, Magnesium has an electronic configuration of 2, 8, 2. It can lose its two valence electrons to achieve a stable octet, thereby forming a Mg^{2+} ion. Lithium forms a +1 ion, Aluminium a +3 ion, and Phosphorus a -3 ion.

31. Match the given chemical elements in List-I with their uniquely correct respective Bohr-Bury electronic configurations in List-II.
List-I
P. Silicon
Q. Sulphur
R. Argon
S. Potassium
List-II
I. 2, 8, 6
II. 2, 8, 8, 1
III. 2, 8, 4
IV. 2, 8, 8
(A) P-III, Q-I, R-IV, S-II
(B) P-I, Q-III, R-II, S-IV
(C) P-III, Q-IV, R-I, S-II
(D) P-II, Q-I, R-III, S-IV

Ans : (A)

Silicon (atomic number 14) properly configures as 2, 8, 4. Sulphur (atomic number 16) routinely configures as 2, 8, 6. Argon (atomic number 18) perfectly stabilizes at 2, 8, 8, while potassium (atomic number 19) uniquely expands configuration to 2, 8, 8, 1.

32. Three naturally occurring isotopes of hydrogen exist, varying strictly by neutron count. Which of these isotopes fundamentally possesses precisely two neutral neutrons within its extremely tiny atomic nucleus?
(A) Protium
(B) Deuterium
(C) Tritium
(D) Hydronium

Ans : (C)

Hydrogen naturally exists in three structurally unique elemental isotopes. Protium exclusively contains zero neutrons, heavier deuterium incorporates exactly one central neutron, and significantly radioactive tritium fundamentally possesses a distinct nucleus accommodating one single proton securely coupled alongside precisely two neutrons.

33. **Assertion (A) :** All three naturally occurring isotopes of standard chlorine chemically undergo the exact same types of chemical reactions.
Reason (R) : Different isotopes of a given element always possess incredibly distinct chemical properties due to widely varying nuclear mass numbers.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

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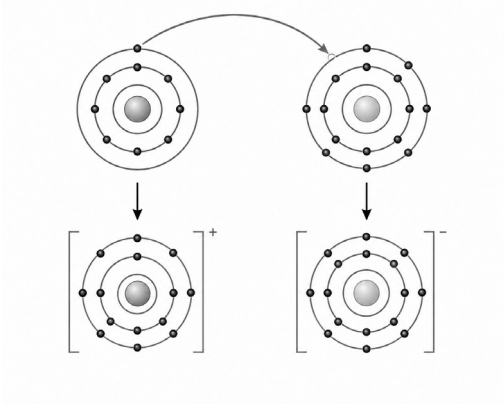
Isotopes universally exhibit flawlessly identical chemical properties precisely because their respective electronic configurations remain profoundly identical. Chemical interactions fundamentally depend exclusively upon these valence electrons, entirely rendering the noticeably different internal nuclear mass numbers completely irrelevant during standardized chemical bonding.

34. The diagram shows two atoms interacting through the complete transfer of an electron from the metallic atom to the non-metallic atom. What type of bond is formed as a result of this interaction?



(A) Covalent bond
(B) Electrovalent bond
(C) Hydrogen bond
(D) Coordinate bond

Ans : (B)

The diagram shows the complete transfer of a valence electron from one atom to another. This process creates a positive ion (cation) and a negative ion (anion). The strong electrostatic force of attraction that holds these oppositely charged ions together is defined as an electrovalent or ionic bond, forming an electrovalent compound.

35. Read the following statements regarding isobars and select the perfectly correct combination.

I. Isobars are elemental atoms possessing drastically different atomic numbers.
II. Isobars possess absolutely identical internal atomic mass numbers.
III. Isobars fundamentally display entirely identical macroscopic physical properties.
IV. Argon-40 and Potassium-40 clearly represent a valid pair of standard isobars.

(A) I, II, and III only
(B) I, II, and IV only
(C) II, III, and IV only
(D) I, III, and IV only

Ans : (B)

Isobars distinctly represent discrete atoms of fundamentally separate elements successfully sharing strictly identical mass numbers alongside completely divergent atomic numbers. Consequently, these elements inherently display distinctly unique chemical and physical properties, perfectly exemplified by the elements Argon-40 and Potassium-40 combined.

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36. Radioactive isotopes play significantly essential roles across highly diverse modern applications. Which of the following specific radioisotopes actively functions as an invaluable primary fuel source inside complex nuclear reactors?

(A) Cobalt-60
(B) Carbon-14
(C) Uranium-235
(D) Iodine-131

Ans : (C)

Various volatile radioisotopes serve completely different functional applications globally. Cobalt-60 successfully provides effective cancer radiotherapy, Carbon-14 reliably dates ancient geological materials, Iodine-131 medically treats thyroid goitre, whereas Uranium-235 critically functions as the foundational combustible fuel operating inside massive nuclear reactors.

37. A purely neutral atom features a remarkably precise fractional atomic mass measured exactly at 35.5. What core scientific reason fundamentally explains why this naturally occurring atomic mass appears distinctly fractional?

(A) The atomic nucleus completely lacks tightly bound neutral internal neutrons.
(B) The atom readily loses valence electrons during continuous atmospheric exposure.
(C) The quoted value accurately reflects a weighted mathematical average of its natural isotopes.
(D) The rapidly moving valence electrons progressively gain relativistic structural mass over time.

Ans : (C)

The fractional atomic mass directly originates from averaging widely distributed naturally occurring elemental isotopes. For precisely example, natural chlorine overwhelmingly contains approximately 75% Chlorine-35 alongside roughly 25% Chlorine-37, effectively rendering its calculated average proportional atomic mass to exactly 35.5 overall.

38. According to Kossel and Lewis, chemical bonding strictly occurs because unstable interacting atoms overwhelmingly desire to practically attain the stable electronic configuration fundamentally characteristic of a specific elemental family. Which family is this?
(A) Alkali metals
(B) Halogens
(C) Alkaline earth metals
(D) Inert gases

Ans : (D)

Kossel and Lewis jointly formulated the fundamental electronic theory of valency. They accurately hypothesized that chemically active atoms inherently combine specifically to obtain the incredibly stable, completely filled octet electronic configuration uniformly exhibited exclusively by the exceptionally unreactive inert gases.

39. During the progressive formation of an electrovalent bond, how does an inherently reactive non-metallic atom fundamentally behave to rapidly secure an ideally stable outer electronic octet configuration?
(A) It permanently transfers its valence electrons directly to a surrounding metallic atom.
(B) It happily shares its innermost core electrons evenly with another identical non-metal.
(C) It reliably accepts one or more external valence electrons from an interacting metallic atom.
(D) It rapidly ejects heavy internal central protons entirely from its positively charged nucleus.

Ans : (C)

Non-metallic atoms naturally feature between five and seven respective outermost valence electrons. During purely electrovalent bonding, these fundamentally electronegative non-metals deliberately accept necessary additional electrons directly from reactive metals, successfully transforming into stably configured, negatively charged chemical species termed anions.

40. **Assertion (A) :** Cation formation fundamentally represents a specific chemical process recognized entirely as active oxidation.
Reason (R) : Oxidation precisely involves the necessary permanent loss of negatively charged electrons from an interacting chemical atom.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

A cation inherently forms precisely when a specific metallic atom completely loses its outermost valence electrons. Because the strict fundamental definition of chemical oxidation exclusively involves the exact procedural loss of electrons, this particular continuous cation formation actively represents pure oxidation.

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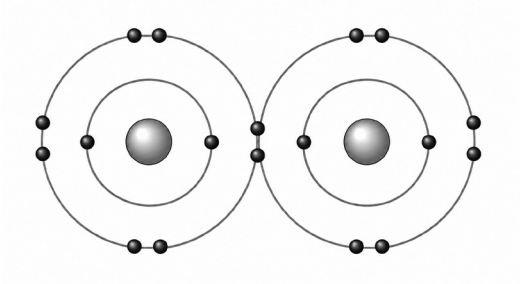
41. In the molecule shown, two atoms have each contributed one electron to form a shared pair, allowing both to achieve a stable octet. What is the resulting bond called?



(A) A single covalent bond
(B) A double covalent bond
(C) An ionic bond
(D) A triple covalent bond

Ans : (A)

When two atoms share one pair of electrons (with each atom contributing one electron to the pair), a single covalent bond is formed. This sharing allows both chlorine atoms in the diagram to complete their valence shell with eight electrons, achieving the stable electronic configuration of the nearest noble gas, Argon.

42. Analyze the detailed electronic configuration of an active sodium atom. What specific sequence of chemical events properly creates a perfectly stable sodium cation (Na^+)?
(A) It gains one external electron to securely complete its outermost M shell.
(B) It deliberately shares two inner electrons with a highly reactive chlorine atom.
(C) It permanently loses its single M shell valence electron, thoroughly exposing a stable L shell octet.
(D) It violently ejects its completely filled K shell to effectively stabilise its remaining internal atomic structure.

Ans : (C)

A neutral sodium atom normally maintains a primary electronic configuration reading 2, 8, 1. To practically achieve superior inert gas stability, the atom permanently loses its lone outermost valence electron, completely changing its stable cation configuration to precisely 2, 8.

43. Which profoundly distinct structural feature definitively characterises the macroscopic physical state of naturally formed solid ionic compounds such as sodium chloride?

(A) They randomly exist as totally independent, widely separated tiny neutral molecules.
(B) They loosely aggregate as weak non-polar symmetrical gas particles closely packed together.
(C) They firmly exist as rigid, closely packed crystalline three-dimensional structural networks of oppositely charged ions.
(D) They steadily form highly soft, easily volatile liquid droplets heavily bonded by extremely weak interactive forces.

Ans : (C)

Ionic compounds decisively avoid existing as totally independent distinct molecules. Instead, they beautifully aggregate as highly solid, structurally rigid crystalline networks meticulously packing together oppositely charged internal cations and adjacent anions deeply locked securely into perfectly ordered geometrical physical spaces.

44. What specific microscopic physical mechanism precisely allows solid ionic chemical compounds to suddenly conduct substantial electricity exclusively when dissolved uniformly into liquid water?

(A) The strong covalent forces permanently lock molecular atomic geometries.
(B) The dissolved solid releases immense excess heat energy that electrically charges the liquid.
(C) The aqueous polar molecules permanently absorb incoming loose electrons generating sudden internal currents.
(D) The strong electrostatic physical bonds rigorously break, finally granting internal ions complete freedom of movement.

Ans : (D)

Completely solid ionic materials strongly resist electrical conduction due to tightly locked static ions. However, whenever properly melted or dissolved, incredibly strong surrounding electrostatic attractions thoroughly shatter, completely allowing liberated charged ions to rapidly drift around and continuously conduct electricity freely.

45. Atoms combine to attain the stable electronic configuration of the nearest noble gas. An atom of Sulphur (S), with configuration 2, 8, 6, forms a stable ion. Which noble gas configuration from the table will this ion have?

Noble Gas	**Atomic Number**	**Electronic Configuration**
Helium (He)	2	2
Neon (Ne)	10	2, 8
Argon (Ar)	18	2, 8, 8
Krypton (Kr)	36	2, 8, 18, 8

(A) Helium
(B) Neon
(C) Argon
(D) Krypton

Ans : (C)

A sulphur atom (2, 8, 6) needs to gain two electrons to complete its outermost shell and achieve a stable octet. By gaining two electrons, its configuration becomes 2, 8, 8. This is the electronic configuration of the noble gas Argon (Ar), which has an atomic number of 18, as shown in the table.

46. Read the following statements detailing covalent chemical bonding carefully and strictly select the definitively incorrect descriptive statement.

(A) Covalent bonds typically form securely between interacting atoms of two diverse non-metals.
(B) Covalent molecular bonding actively involves the strict mutual sharing of external valence electrons.
(C) Each actively bonding atom reliably contributes an entirely equal number of shared pair electrons.
(D) Covalent bonding intrinsically involves the complete permanent transfer of valence electrons leaving residual charges.

Ans : (D)

Covalent bonding exclusively demands the strictly equal mutual sharing of available valence electrons securely existing between identical or similar non-metallic atoms. Complete permanent electron physical transfer characterizes completely different ionic bonding mechanisms, generating discrete cations and anions instead of neutral molecules.

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47. Match the specific covalent molecules presented in List-I precisely with their structurally corresponding chemical bond types shown accurately within List-II.

List-I

P. Hydrogen (H_2)

Q. Oxygen (O_2)

R. Nitrogen (N_2)

S. Ethene (C_2H_4)

List-II

I. One double bond and four single bonds

II. Single covalent bond

III. Triple covalent bond

IV. Double covalent bond

(A) P-II, Q-IV, R-III, S-I

(B) P-III, Q-I, R-IV, S-II

(C) P-II, Q-III, R-I, S-IV

(D) P-I, Q-IV, R-II, S-III

Ans : (A)

The standard hydrogen molecule exclusively features one distinct single covalent bond. The oxygen molecule definitively exhibits a stable double covalent bond. A structurally rigid nitrogen molecule successfully utilizes a uniquely strong triple covalent bond, while ethene simultaneously possesses both bond types.

48. Isobars are atoms of different elements with the same mass number. Based on the data provided for the four atomic species, identify the pair of isobars.

Species	**Atomic Number (Z)**	**Mass Number (A)**
W	18	40
X	17	35
Y	19	40
Z	17	37

(A) W and X

(B) X and Z

(C) W and Y

(D) Y and Z

Ans : (C)

Isobars are defined as atoms having the same mass number (A) but different atomic numbers (Z). The table shows that species W (Argon) and Y (Potassium) both have a mass number of 40, but their atomic numbers are different (18 and 19 respectively). Therefore, W and Y are a pair of isobars.

49. Consider the perfectly symmetrical electronic distribution within a stable chlorine molecule (Cl_2). How many complete shared pairs of interactive valence electrons effectively exist solidly between the two structurally participating chlorine atoms?

(A) One shared pair

(B) Two shared pairs

(C) Three shared pairs

(D) Four shared pairs

Ans : (A)

A standard neutral chlorine atom fundamentally possesses seven functional outermost valence electrons. By mutually sharing exactly one electron each, the two dynamically engaged chlorine atoms structurally form exactly one distinct shared pair, completely creating a singular, incredibly stable non-polar covalent bond.

50. Polar covalent chemical compounds structurally exhibit a highly specific distribution pattern of mutually shared valance electron pairs. Which exact descriptive feature strictly characterises a fundamentally polar covalent bond?

(A) The shared electron pair systematically resides perfectly equidistant completely between the two atoms.

(B) The interactive shared electron pair rests absolutely closer strictly toward the significantly less electronegative combining atom.

(C) The actively shared electron pair sits physically closer distinctly toward the demonstrably more electronegative combining atom.

(D) The continuously shared electron pair gets permanently ejected from both atomic shells completely forming discrete plasma.

Ans : (C)

In definitively polar covalent molecules, the carefully shared pair of bonding valence electrons firmly remains unequally spaced physically between combining atoms. The highly shared electrons naturally rest measurably closer toward the noticeably more electronegative atomic nucleus, thus producing distinct partial molecular charges.

51. A properly formed hydrogen chloride molecule exhibits distinct polar covalent bonding characteristics. Which specific stable inert noble gas electronic configuration does the participating chlorine atom ultimately acquire following this sharing?

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(A) Helium
(B) Neon
(C) Argon
(D) Krypton

Ans : (C)

A standard neutral chlorine atom actively holds a designated 2, 8, 7 electronic configuration. By dynamically sharing exactly one additional interactive electron closely with the approaching hydrogen atom, the chlorine structurally attains the incredibly stable 2, 8, 8 outermost configuration uniquely matching argon.

52. A student listed the properties of three fundamental particles of an atom. Analyse the table to identify the particles P, Q, and R.

Particle	Relative Charge	Location in Atom
P	+1	Inside Nucleus
Q	-1	Outside Nucleus
R	0	Inside Nucleus

(A) P is Neutron, Q is Electron, R is Proton
(B) P is Proton, Q is Electron, R is Neutron
(C) P is Electron, Q is Proton, R is Neutron
(D) P is Proton, Q is Neutron, R is Electron

Ans : (B)

Particle P, with a +1 charge and located in the nucleus, is a proton. Particle Q, with a -1 charge and located outside the nucleus, is an electron. Particle R, with a 0 charge and located in the nucleus, is a neutron. The other options incorrectly match the particles with their established properties.

53. Examine the detailed structural formation of a completely stable standard water molecule (H_2O). How many completely independent single covalent chemical bonds successfully connect the designated participating atomic elements within this structure?
(A) One
(B) Two
(C) Three
(D) Four

Ans : (B)

Within a stable standard water molecule, the single central oxygen atom systematically shares its dual available valence electrons distinctly with precisely two separate hydrogen atoms individually. This perfectly symmetrical geometric mutual sharing creates exactly two structurally discrete, highly robust single covalent bonds.

54. Read the following statements critically regarding the fundamental physical properties of typically formed covalent chemical compounds and properly select the single correct combination.
I. Covalent compounds typically demonstrate remarkably exceptionally high melting and high boiling points.
II. Covalent chemical compounds exist overwhelmingly as individual independent molecular structures.
III. Covalent compounds inherently dissolve profoundly well strictly into standard liquid water.
IV. Covalent bonds strictly display intensely directional physical alignments resulting strongly in predictable spatial isomerism.
(A) I and II only
(B) II and IV only
(C) I, II, and III only
(D) II, III, and IV only

Ans : (B)

Standard covalent chemical compounds consistently form completely independent molecules securely held entirely by inherently weak intermolecular cohesive forces. Because these precisely shared localized bonds remain powerfully directional, such volatile elements effortlessly display relatively low boiling points alongside complex, highly predictable spatial isomerism.

55. A single neutral methane molecule essentially contains uniquely designated numbers of discrete atomic chemical elements expertly bound closely together. Carefully calculate the absolute total number of chemically active single atoms physically contained entirely within a perfectly formed methane molecule.
(A) Three
(B) Four
(C) Five
(D) Six

Ans : (C)

A typical, optimally structured methane molecule (CH4) incorporates strictly one single centralized carbon atom systematically surrounded physically by precisely four individually attached adjacent hydrogen atoms. Adding these elemental parts mathematically together perfectly reveals a total geometric composition featuring precisely five completely distinct atoms.

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56. What highly specific physical term precisely indicates the definite absolute total count of shared valence electrons that one individual reactive elemental atom actively contributes directly toward mutual covalent molecular bonding?
(A) Electrovalency
(B) Covalency
(C) Ionization capacity
(D) Nuclear magnitude

Ans : (B)

The strictly defined chemical term basically known entirely as covalency perfectly references the absolute maximum numerical quantity of distinct individual valence electrons an active chemical atom systematically provides openly to successfully formulate interactive, structurally vital shared electron pairs during molecular bonding.

57. An element's average atomic mass is the weighted average of its naturally occurring isotopes. Given the data for Element X, calculate its average atomic mass.

Isotope	Mass Number	Natural Abundance (%)
X-35	35	75
X-37	37	25

(A) 35.0
(B) 35.5
(C) 36.0
(D) 37.0

Ans : (B)

The average atomic mass is calculated as the sum of (mass of each isotope × its fractional abundance).
Average mass

$$= (35 \times 0.75) + (37 \times 0.25)$$

$$= 26.25 + 9.25 = 35.5.$$

This calculation accounts for the different proportions of each isotope found in nature, resulting in a fractional average atomic mass for the element.

58. In standard atomic structural modelling, an atomic subshell designated essentially as the antepenultimate shell technically refers precisely to which specifically situated internal orbital level?
(A) The outermost external valence shell.
(B) The immediately inner shell positioned exactly next to the outermost valence shell.
(C) The precisely located last but precisely two internal structural shells.
(D) The absolute innermost fundamental core subshell securely positioned strictly adjacent to the nucleus.

Ans : (C)

Following rigorous Bohr-Bury electronic atomic filling principles carefully, the distinctly designated outermost atomic orbit is firmly named the valence shell. The strictly inner orbit positioned firmly prior is technically called the penultimate shell, whereas the shell located exactly preceding that becomes mathematically the antepenultimate shell.

59. Identify the highly distinctive, profoundly extreme chemical compound specifically referenced fundamentally by academic chemists universally as possessing the absolute maximum naturally possible ionic characteristic due to perfectly maximized atomic electron loss and simultaneous energetic electron gain.
(A) Calcium oxide
(B) Sodium chloride
(C) Potassium bromide
(D) Caesium fluoride

Ans : (D)

Caesium fluoride fundamentally operates chemically as the absolute universally most completely ionic compound existing practically. Extreme metallic caesium intrinsically exhibits perfectly maximal electropositive tendency eagerly losing an electron entirely, whereas highly reactive non-metallic fluorine perfectly demonstrates simultaneously maximal electronegative electron-accepting capacity inherently.

60. Read the critically important statements listed below exclusively regarding standard carbon tetrachloride (CCl_4) chemical molecules structurally, then actively identify the solely incorrect factual statement.
(A) It strictly represents an entirely non-polar purely covalent chemical compound structurally.
(B) The singular central carbon atom thoroughly attains stable noble neon gas configurations perfectly.
(C) Four distinct single internal covalent bonds securely bind the central carbon firmly to the halogens.
(D) The completely combined resulting molecule effortlessly conducts immense continuous electrical currents natively.

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Ans : (D)

Perfectly symmetric non-polar carbon tetrachloride naturally functions fundamentally as a perfectly stable pure covalent structural molecule actively composed totally of securely neutral participating non-metallic atoms. Due to inherently lacking highly mobile detached internal conductive ions completely, it inherently absolutely cannot conduct practically any electricity.

61. The diagrams represent three different atoms of hydrogen. What is the fundamental difference between these three atoms?

(A) The number of protons.
(B) The number of neutrons.
(C) The number of electrons.
(D) The chemical properties.

Ans : (B)

The three diagrams show Protium (1p, 0n), Deuterium (1p, 1n), and Tritium (1p, 2n). These are isotopes of hydrogen. By definition, isotopes of an element have the same number of protons (and thus the same atomic number and chemical properties) but differ in their number of neutrons, leading to different mass numbers.

62. During standard, perfectly stable atomic formation regarding basic calcium oxide ionic crystalline compounds, how many specific reactive outermost valence electrons distinctly physically transfer directly out from the intensely reactive participating central metallic calcium atom itself?

(A) One electron completely transfers.
(B) Two electrons fundamentally transfer.
(C) Three electrons deliberately transfer.
(D) Four electrons predictably transfer.

Ans : (B)

A highly reactive neutral metallic calcium atom strictly holds exactly two highly mobile outer functional valence electrons securely resting in its completely exposed N shell. It deliberately physically transfers precisely both available electrons entirely over directly toward oxygen perfectly forming a stable divalent cation.

63. Consider carefully the distinctly contrasting naturally diverse elemental atoms listed comprehensively below. Accurately identify which unique chemical element fundamentally functionally possesses exactly triple reactive valence electrons inherently circling continuously within its perfectly neutral naturally unbonded structural configuration natively.

(A) Boron
(B) Magnesium
(C) Sulphur
(D) Chlorine

Ans : (A)

The strictly typical naturally active chemical element basically known exclusively as solid neutral boron fundamentally holds precisely five native protons alongside an actively balancing stable set consisting precisely of five circling electrons systematically arranging securely directly into an exact stable 2, 3 electronic configuration natively.

64. Match the exact numerical descriptive capacities strictly detailing Bohr's uniquely stable permitted atomic shells firmly contained securely within List-I directly toward their mathematically calculated absolute electron holding capacities flawlessly listed sequentially directly inside List-II carefully.

List-I
P. K shell
Q. L shell
R. M shell
S. N shell

List-II
I. 18 electrons
II. 32 electrons
III. 8 electrons
IV. 2 electrons

(A) P-IV, Q-III, R-I, S-II
(B) P-III, Q-I, R-IV, S-II
(C) P-IV, Q-I, R-III, S-II
(D) P-I, Q-II, R-III, S-IV

Ans : (A)

Strictly implementing the highly exact mathematically robust $2n^2$ structural distribution principle effectively accurately permits precisely two internal fundamental electrons safely populating inside the K shell, strictly eight precisely occupying the larger adjacent L shell, accurately eighteen distinctly populating the M shell, and completely thirty-two uniquely within the N shell.

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65. Who discovered the electron?
(A) Rutherford
(B) Chadwick
(C) J.J. Thomson
(D) Goldstein

Ans : (C)

Explanation: J.J. Thomson discovered the electron through cathode ray experiments. This discovery proved that atoms are not indivisible, as previously suggested by Dalton. Electrons are negatively charged particles present outside the nucleus. Their discovery marked the beginning of modern atomic theory and led to further investigations into the internal structure of the atom.

66. Why is an atom electrically neutral?
(A) It contains neutrons only
(B) It has equal numbers of protons and electrons
(C) It has no charged particles
(D) Electrons have no charge

Ans : (B)

Explanation: An atom contains positively charged protons and negatively charged electrons. Since the number of protons equals the number of electrons in a neutral atom, the positive and negative charges cancel each other. Therefore, the atom has no net charge and remains electrically neutral.

67. Which scientist discovered the nucleus?
(A) Chadwick
(B) Bohr
(C) Rutherford
(D) Thomson

Ans : (C)

Explanation: Ernest Rutherford discovered the nucleus through his famous alpha-particle scattering experiment. He observed that most alpha particles passed straight through a gold foil, while a few were deflected. This led him to conclude that most of the atom is empty space and that a small, dense, positively charged nucleus exists at the centre.

68. What was the major drawback of Rutherford's atomic model?
(A) It did not contain electrons
(B) It could not explain atomic stability
(C) It ignored neutrons
(D) It was based on atomic mass

Ans : (B)

Explanation: According to Rutherford's model, electrons revolve around the nucleus. Based on electromagnetic theory, moving charged particles should continuously lose energy and eventually fall into the nucleus. Since atoms are stable in reality, Rutherford's model failed to explain this stability, which was later addressed by Bohr's model.

69. According to Bohr's model, electrons revolve in:
(A) Random paths
(B) Fixed orbits
(C) Straight lines
(D) Nucleus

Ans : (B)

Explanation: Bohr proposed that electrons revolve around the nucleus in fixed circular paths called shells or energy levels. While moving in these fixed orbits, electrons neither gain nor lose energy. This concept successfully explained why atoms remain stable and do not collapse as predicted by Rutherford's model.

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70. What are quanta?
(A) Atomic particles
(B) Nuclei
(C) Packets of energy
(D) Isotopes

Ans : (C)

Explanation: Quanta are discrete packets of energy absorbed or emitted by electrons. When an electron jumps from a lower energy level to a higher one, it absorbs energy in the form of quanta. Similarly, when it returns to a lower level, it releases energy as quanta. This concept was introduced in Bohr's atomic theory.

71. An atom has atomic number 17 and mass number 35. How many neutrons does it contain?
(A) 17
(B) 18
(C) 35
(D) 52

Ans : (B)

Explanation: Number of neutrons = Mass Number - Atomic Number. Therefore, neutrons = 35 - 17 = 18. Atomic number represents the number of protons, while mass number is the sum of protons and neutrons present in the nucleus of an atom.

72. What is the electronic configuration of sodium (Atomic Number 11)?

(A) 2,8,1
(B) 2,8,2
(C) 2,7,2
(D) 2,6,3

Ans : (A)

Explanation: Sodium contains 11 electrons. According to the Bohr-Bury scheme, the first shell accommodates 2 electrons, the second shell 8 electrons and the remaining electron enters the third shell. Thus, its electronic configuration is 2,8,1. This single valence electron makes sodium highly reactive.

73. Which type of bond is formed by the transfer of electrons?
(A) Covalent bond
(B) Metallic bond
(C) Ionic bond
(D) Hydrogen bond

Ans : (C)

Explanation: An ionic or electrovalent bond is formed when electrons are transferred from a metal atom to a non-metal atom. The metal loses electrons to form positively charged ions (cations), while the non-metal gains electrons to form negatively charged ions (anions). The electrostatic attraction between these ions forms the ionic bond.

74. Which molecule contains a triple covalent bond?
(A) H_2
(B) O_2
(C) Cl_2
(D) N_2

Ans : (D)

Explanation: Nitrogen has five valence electrons and requires three more electrons to complete its octet. Two nitrogen atoms share three pairs of electrons, forming a triple covalent bond. This bond is represented as N≡N and is stronger than single and double covalent bonds found in molecules such as H_2 and O_2.

ONE MARK QUESTIONS

75. Why isotopes have same chemical properties?

Ans :

(A) they have same number of valence electrons.

76. What common feature in electronic configuration is seen in argon and neon?

Ans :

Both of them have eight electrons in their outermost shell, i.e. having stable configuration following the octet rule.

77. Define electronic configuration.

Ans :

The arrangement or distribution of electrons in various energy levels or shells.

78. Why do covalent compounds exist as gases, liquids or soft solids?

Ans :

The force of attraction between the constituent particles is weak.

79. Why the electronic configurations of potassium and calcium are 2, 8, 8, 1 and 2, 8, 8, 2 but not 2, 8, 9 and 2, 8, 10 respectively?

Ans :

According to Bohr–Bury scheme of electronic configuration, the next shell begins as soon as the last shell acquires eight electrons.

80. Why hydrogen chloride can be termed a polar covalent compound?

Ans :

Chlorine is more electronegative than hydrogen, therefore, the shared pair of electrons lies closer to chlorine and hence the bond becomes polar.

81. What are valence electrons? How valence electrons help to predict the nature of the element?

Ans :

The electrons present in the outermost shell of an atom are called valence electrons. Metals have 1, 2 or 3 valence electrons, Non-metals have 5, 6 or 7 valence electrons Inert gases have 8 valence electrons.

DIRECTION : Fill in the blank

82. Name the particle which was bombarded on gold foil by Rutherford for discovery of nucleus.

Ans :

Alpha (α) particle

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83. Electrovalent compounds have _____ (high/low) melting points.

Ans :

High.

84. State reason for an element to have atoms with different mass number.

Ans :

(A) they have different number of neutrons.

85. An element L consists of molecules. What type of bonding is present in the particles that make up L ?

Ans :

Covalent bonding

86. Calculate the number of neutrons in (i) ${}^{3}_{1}H$ (ii) ${}^{40}_{18}Ar$ and (iii) ${}^{235}_{92}U$.

Ans :

(i) 2
(ii) 22
(iii) 143

87. How does the mass of a proton compare with the mass of (i) an atom of hydrogen (ii) an electron?

Ans :

(i) Mass of a proton = Mass of a hydrogen atom

(ii) Mass of an electron = $\frac{1}{1837}$ mass of proton.

88. Fill in the blanks from the given choices:

(i) In covalent compounds, the bond formed is due to the _____ (sharing/transfer) of electrons.

(ii) Electrovalent compounds have _____ (high/low) boiling point.

Ans :

(i) sharing (ii) high.

89. Give reasons:

(i) Atoms combine by transferring electrons.

(ii) Inert elements exist as monoatoms in molecules.

Ans :

(i) Each and every atom tries to attain the configuration of nearest inert gas by losing electrons or gaining electrons from their outermost shell.

(ii) Inert gases have complete octet, i.e. they have stable configuration, thus, their combining capacity is zero.

90. Fill in the blanks.

(i) The maximum number of electrons that can be accommodated in each shell is _____.

(ii) Metals have _____, _____ or _____ electrons in their valence shell.

(iii) Isotopes are the atoms of _____ having same _____ but different _____.

(iv) Isotopes differ in the number of _____.

(v) _____ and _____ are collectively called nucleons.

Ans :

(i) $2n^2$
(ii) 1, 2, 3
(iii) Same element, atomic number, mass number
(iv) neutrons
(v) protons, neutrons

91. Fill in the blanks:

(i) _____ is the smallest particle which takes part in a chemical reaction.

(ii) _____ is a fundamental particle having mass equal to hydrogen atom.

(iii) Neutrons were discovered by _____.

(iv) The maximum number of electrons in any shell is given by the formula _____.

(v) Hydrogen has _____ isotopes.

Ans :

(i) Atom (ii) Proton
(iii) Chadwick (iv) $2n^2$
(v) three

92. Write the electronic configurations, number of valence electrons and classify the following as metals, non-metals and inert gases.

(i) ${}^{24}_{12}P$ (ii) ${}^{39}_{19}Q$
(iii) ${}^{14}_{7}R$ (iv) ${}^{40}_{18}S$
(v) ${}^{16}_{8}T$

Ans :

	Electronic Configuration					
Element	**K**	**L**	**M**	**N**	**Valence Electrons**	**Type of Element**
(i) P	2	8	2		2	Metal
(ii) Q	2	8	8	1	1	Metal
(iii) R	2	5			5	Non-metal
(iv) S	2	8	8		8	Inert gas
(v) T	2	6			6	Non-metal

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93. Copy and complete the following table.

Isotopes of hydrogen	Mass no.	Atomic no.	Protons	Electrons	Neutrons
Protium	1	1	–	–	–
–	2	1	–	–	–
–	3	–	–	–	–

Ans :

Isotopes of hydrogen	Mass no.	Atomic no.	Protons	Electrons	Neutrons
Protium	1	1	1	1	0
Deuterium	2	1	1	1	1
Tritium	3	1	1	1	2

94. Complete the following:

Particles	**Symbol**	**Charge**	**Mass**
Electron	–	–	–
Proton	–	–	–
Neutron	–	–	–

Particles	Symbol	Charge	Mass
Electron	e	-1	$\frac{1}{1837}$ amu
Proton	p	$+1$	1 amu
Neutron	n	0	1 amu

95. Choose from the following, the ionic bond and the covalent bond:

(a) NaCl
(b) Methane
(c) Oxygen molecule
(d) Hydrogen chloride gas
(e) Calcium oxide
(f) Ammonia

Ans :

(a)	NaCl	Ionic bond
(b)	Methane	Covalent bond
(c)	Oxygen molecule	Covalent bond
(d)	Hydrogen chloride gas	Covalent bond
(e)	Calcium oxide	Ionic bond
(f)	Ammonia	Covalent bond

96. Name the following:

(a) The type of bonding present in metallic chlorides.
(b) The type of bonding present in non-metallic chlorides.
(c) The bond formed by the mutual sharing of electrons.
(d) The bond formed by the transfer of electrons.

Ans :

(a) Ionic or electrovalent bonding
(b) Covalent bonding
(c) Covalent bond
(d) Ionic bond

97. Identify the type of bond expected to be formed between the pair of elements with the following atomic numbers. Identify the elements and predict their formula also.

(i) 1, 17 (ii) 11, 9
(iii) 6, 1 (iv) 20, 1

Ans :

	Atomic Number	Name of element	Type of bond	Formula
(i)	1	Hydrogen	Polar covalent bond	HCl
	17	Chlorine		
(ii)	11	Sodium	Ionic bond	NaF
	9	Fluorine		
(iii)	6	Carbon	Non-polar covalent bond	CH_4
	1	Hydrogen		
(iv)	20	Calcium		CaH_2
	1	Hydrogen	Ionic bond	

98. Match the following:

Column I (Shells)		**Column II (Maximum electrons)**	
(i)	K-shell	(a)	8
(ii)	L-shell	(b)	32
(iii)	M-shell	(c)	2
(iv)	N-shell	(d)	18

Ans :

Column I (Shells)		**Column II (Maximum electrons)**	
(i)	K-shell	(c)	2
(ii)	L-shell	(a)	8
(iii)	M-shell	(d)	18
(iv)	N-shell	(b)	32

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99. State whether the following statements are True or False.

(i) Atomic number is the total number of electrons present inside the nucleus of an atom.
(ii) The protons are negatively charged particles.
(iii) Mass of an atom is concentrated inside the nucleus of an atom.
(iv) Helium has a complete octet.
(v) Deuterium is the isotope of hydrogen.

Ans :

(i) False (ii) False (iii) True
(iv) False (v) True

100. Match the following -

	Column I (Element)		**Column II (Electronic configuration)**
(i)	Phosphorus	(a)	2, 8, 8
(ii)	Argon	(b)	2, 8, 8, 2
(iii)	Sodium	(c)	2, 8, 4
(iv)	Calcium	(d)	2, 8, 5
(v)	Silicon	(e)	2, 8, 1

Ans :

	Column I (Element)		**Column II (Electronic configuration)**
(i)	Phosphorus	(d)	2, 8, 5
(ii)	Argon	(a)	2, 8, 8
(iii)	Sodium	(e)	2, 8, 1
(iv)	Calcium	(b)	2, 8, 8, 2
(v)	Silicon	(c)	2, 8, 4

101. Complete the following table.

S.No.	**Element**	**Electronic configuration**
(i)	Potassium	2, 8, —, —
(ii)	————	2, 8, 2
(iii)	Chlorine	2, —, —
(iv)	Neon	2, —,
(v)	————	1

Ans :

S.No.	**Element**	**Electronic configuration**
(i)	Potassium	2, 8, 8, 1
(ii)	magnesium	2, 8, 2
(iii)	Chlorine	2, 8, 7
(iv)	Neon	2, 8
(v)	Hydrogen	1

102. An atom of an element is represented as $^{39}_{19}X$.

(i) What does value 39 indicate?
(ii) What does value 19 indicate?
(iii) What is the number of protons in X?
(iv) What is the number of electrons in X?
(v) What is the number of neutrons in X ?
(vi) Give the electronic configuration of element X.
(vii) State the valence electrons in element X.
(viii) Is element X metal or non-metal?

Ans :

(i) Mass number of X
(ii) Atomic number of X
(iii) 19
(iv) 19
(v) 20
(vi) 2, 8, 8, 1
(vii) 1
(viii) Metal.

103. Write the electronic configurations of the following elements and write the number of valence electrons present in it.

(i) $^{14}_{7}N$ (ii) $^{16}_{8}O$
(iii) $^{28}_{14}Si$ (iv) $^{40}_{20}Ca$
(v) $^{40}_{18}Ar$ (vi) $^{9}_{4}Be$
(vii) $^{12}_{6}C$ (viii) $^{31}_{15}P$
(ix) $^{32}_{16}S$ (x) $^{35}_{17}Cl$

Ans :

	Electronic Configuration				
Element	**K**	**L**	**M**	**N**	**Valence Electrons**
(i) N	2	5			5
(ii) O	2	6			6
(iii) Si	2	8	4		4
(iv) Ca	2	8	8	2	2

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(v) Ar	2	8	8		8
(vi) Be	2	2			2
(vii) C	2	4			4
(viii) P	2	8	5		5
(ix) S	2	8	6		6
(x) Cl	2	8	7		7

104. Give reasons why
(i) atom is electrically neutral.
(ii) mass of an atom is concentrated inside the nucleus of an atom.
(iii) atom as a whole is an empty space.
(iv) Rutherford model of atom could not provide stability to the nucleus.

Ans :
(i) An atom is electrically neutral because the number of positively charged particles (protons) is equal to the number of negatively charged particles (electrons).
(ii) Mass of an atom is contributed by the mass of the protons and neutrons present inside the nucleus of an atom and the electrons present outside the nucleus are of negligible mass, therefore, mass of an atom is concentrated inside the nucleus of an atom.
(iii) The size of the nucleus is very small as compared to the size of an atom, therefore, atom as a whole is an empty space.
(iv) According to Rutherford, the protons are present inside the nucleus and electrons are revolving around the nucleus. Electron continuously loses energy and ultimately it falls into the nucleus following a spiral path and thus, the nucleus of an atom gets destroyed.

105. Fill in the blanks:
(i) The electrons present in the outermost shell of an atom are called _____ electrons.
(ii) Inert gases have _____ electrons in the _____ shell.
(iii) Metals have _____, _____ or _____ electrons in their valence shell.
(iv) Non-metals have _____, _____ or _____ electrons in their valence shell.
(v) Metals are _____ in nature.
(vi) Non-metals are _____ in nature.
(vii) During chemical reaction only _____ electrons participate.
(viii) Inert gas not having _____ electrons in the valence shell is _____.
(ix) Metals form _____.
(x) Non-metals form _____.

Ans :
(i) valence
(ii) 8, outermost/valence
(iii) 1, 2, 3
(iv) 5, 6, 7
(v) electropositive
(vi) electronegative
(vii) valence
(viii) 8, helium
(ix) cations
(x) anions.

106. Fill in the blanks:
(i) The maximum number of electrons that can be accommodated in each shell according to Bohr-Bury scheme is _____.
(ii) The first shell is _____ shell. It can accommodate only _____ electrons.
(iii) Atomic number is equal to the number of _____present inside the nucleus of an atom.
(iv) Number of neutrons are calculated by taking difference of _____ and _____.
(v) An atom is electrically _____ as the number of _____ are equal to the number of _____.
(vi) Mass of an atom is concentrated inside the _____ of an atom.
(vii) Size of the _____ is very small as compared to the size of an atom.
(viii) Atom as a whole is an _____ space.
(ix) Electrons are _____ charged particles.
(x) Protons are _____ charged particles.
(xi) Neutrons are electrically _____.
(xii) Nucleus was discovered by _____.
(xiii) Electrons possess unit _____ charge.
(xiv) Protons possess unit _____ charge.
(xv) The electrons are of _____ mass.

Ans :
(i) $2n^2$
(ii) K, 2 (two)
(iii) protons
(iv) mass number and atomic number
(v) neutral, protons, electrons
(vi) nucleus
(vii) nucleus
(viii) empty
(ix) negatively
(x) positively
(xi) neutral

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(xii) Rutherford
(xiii) negative
(xiv) positive
(xv) negligible

107. Give reasons why
(i) Metals are monoatomic.
(ii) Inert gases are monoatomic.
(iii) Inert gases have zero valency.
(iv) The valency of sodium is +1.
(v) The valency of chlorine is –1.
(vi) Inert gases are chemically inactive.
(vii) Isotopes have similar chemical properties.

Ans :

(i) Metals are monoatomic because metals have 1, 2 or 3 electrons in their valence shell hence they complete their octet by losing electrons not by mutual sharing of electrons.

(ii) Inert gases have complete duplet or octet, so, they have no tendency to gain, lose or share electrons, hence they are monoatomic.

(iii) Inert gases have complete duplet or octet so, they can neither lose electrons nor they can gain electrons and hence their valency is zero.

(iv) The electronic configuration of sodium is 2, 8, 1. In order to complete its octet, sodium loses one electron and thus acquires a monopositive valency.

$$Na - e^- \longrightarrow Na^+$$

2, 8, 1 ..... 2, 8

(v) The electronic configuration of chlorine is 2, 8, 7. In order to complete its octet, chlorine gains one electron and thus gets converted to mononegative ion.

$$Cl + e^- \longrightarrow Cl^-$$

2, 8, 7 ..... 2, 8, 8

(vi) Inert gases have complete octet, i.e. eight electrons in the outermost shell (except helium which has two electrons), hence they have no tendency to lose, gain or share electrons, therefore, they are chemically inert.

(vii) Isotopes have similar chemical properties because they have same atomic number hence same number of protons and, therefore, same electronic configurations, leading to the same number of valence electrons.

108. Define the following:
(i) Electropositive elements
(ii) Electronegative elements
(iii) Valence electrons
(iv) Electronegativity
(v) Isotopes
(vi) Isobars
(vii) Electronic configuration
(viii) Chemical bond.

Ans :

(i) Electropositive elements: The elements which lose electrons and get converted to positively charged particles are called electropositive elements. Metals are called electropositive elements as they can lose their 1, 2 or 3 electrons present in their valence shell to complete its octet, and get converted to positively charged particles called cations.

(ii) Electronegative elements: The elements which gain electrons and get converted to negatively charged particles are called electronegative elements. Non-metals are called electronegative elements. Non-metals have 5, 6 or 7 electrons in their valence shell so as to complete their octet, they gain electrons and get converted to negatively charged particles called anions.

(iii) Valence electrons: Electrons present in the outermost shell of an atom.

(iv) Electro-negativity: It is the tendency on the part of an atom to attract the shared pair of electrons towards its side during covalent bond formation.

(v) Isotopes: These are the atoms of same element having same atomic number but different mass number.

(vi) Isobars: These are the atoms of different elements having same mass number but different atomic number.

(vii) Electronic configuration: The arrangement or the distribution of electrons in various energy levels or shells is called electronic configuration.

(viii) Chemical bond: The force of attraction which holds the different particles together in a molecule is called chemical bond.

TWO MARKS QUESTIONS

109. Why is an atom electrically neutral despite containing charged particles?

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Ans :

(i) Number of protons equals the number of electrons.
(ii) Positive and negative charges cancel each other.

110. What observation from Rutherford's experiment proved that an atom is mostly empty space?

Ans :

(i) Most alpha particles passed straight through the gold foil.
(ii) This showed that most of the atom is empty space.

111. Why did Rutherford conclude that the nucleus is positively charged?

Ans :

(i) Some positively charged alpha particles were deflected.
(ii) Therefore, the nucleus must contain positive charge.

112. State one drawback of Rutherford's atomic model.

Ans :

(i) It could not explain the stability of atoms.
(ii) Revolving electrons should have fallen into the nucleus.

113. According to Bohr's model, why do electrons not lose energy while revolving around the nucleus?

Ans :

(i) Electrons move in fixed energy levels.
(ii) In these orbits, they neither gain nor lose energy.

114. What are quanta?

Ans :

(i) Quanta are packets of energy.
(ii) Electrons absorb or emit energy in the form of quanta.

115. Define atomic number.

Ans :

(i) Atomic number is the number of protons in the nucleus.
(ii) It is equal to the number of electrons in a neutral atom.

116. An atom has atomic number 17 and mass number 35. Calculate the number of neutrons.

Ans :

(i) Number of neutrons
= Mass number – Atomic number
(ii) = 35 – 17 = 18

117. Write the electronic configuration of sodium (Atomic Number 11).

Ans :

(i) K-shell = 2 electrons
(ii) L-shell = 8 electrons,
M-shell = 1 electron → 2,8,1

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118. What are valence electrons?

Ans :

(i) Electrons present in the outermost shell.
(ii) They participate in chemical bonding.

119. Why are noble gases chemically inactive?

Ans :

(i) Their outermost shell is completely filled.
(ii) They already possess stable electronic configuration.

120. Define isotopes.

Ans :

(i) Atoms of the same element having the same atomic number.
(ii) But different mass numbers.

121. Why do isotopes have similar chemical properties?

Ans :

(i) They have the same atomic number.
(ii) Therefore, they have the same electronic configuration.

122. Why do isotopes have different physical properties?

Ans :

(i) They have different mass numbers.
(ii) They contain different numbers of neutrons.

123. Why does chlorine have a fractional atomic mass of 35.5?

Ans :

(i) Chlorine exists as two isotopes: Cl-35 and Cl-37.
(ii) Its atomic mass is the weighted average of the two isotopes.

124. What is a cation?

Ans :

(i) A positively charged ion.
(ii) It is formed by the loss of electrons.

125. What is an anion?

Ans :

(i) A negatively charged ion.
(ii) It is formed by the gain of electrons.

126. Why are metals called electropositive elements?

Ans :

(i) Metals lose electrons easily.
(ii) They form positively charged ions.

127. What is an ionic bond?

Ans :

(i) It is formed by transfer of electrons.
(ii) It is usually formed between a metal and a non-metal.

128. What is a covalent bond?

Ans :

(i) It is formed by mutual sharing of electrons.
(ii) It is usually formed between non-metal atoms.

129. Who discovered neutrons? Write the mass and charge of a neutron.

Ans :

Chadwick, no charge, (neutral) and mass is equal to the mass of one atom of hydrogen.

130. An element is represented by symbol $^{23}_{11}X$.
(i) What is the mass number and atomic number?
(ii) Find the number of electrons, protons and neutrons.

Ans :

(i) Atomic number is 11, Mass number is 12.
(ii) Electrons = 11,
Protons = 11 and neutrons = 12

131. Which electron has maximum and minimum energy?
(i) Electron present in K-shell
(ii) Electron present in N-shell

Ans :

(i) The electron present in K-shell has the minimum energy
(ii) The electron present in N-shell has the maximum energy.

132. An atom of an element has three electrons in the M-shell. What is
(i) The atomic number of this element?
(ii) The number of protons present in this element?

Ans :

(i) Atomic number = 13
(ii) Number of protons = 13.

133. Write the electronic configuration of
(i) $^{35}_{17}Cl$ (ii) $^{31}_{15}P$
(iii) $^{39}_{19}K$ (iv) $_{20}Ar^{40}$

Ans :

(i) 2, 8, 7 (ii) 2, 8, 5
(iii) 2, 8, 8, 1 (iv) 2, 8, 8

134. Amongst the electrons revolving around the nucleus, which electron will determine chemical properties of an element. Give reason.

Ans :

In a chemical reaction, only valence electrons are involved because each atom tries to attain the configuration of nearest inert gas to become stable by sharing or transferring electrons and for this, only valence electrons are shared or transferred.

135. State the type of bond present in:
(i) Non-metallic chloride
(ii) Metallic chloride
(iii) Chlorine molecule
(iv) Nitrogen molecule

Ans :

(i) Covalent bond
(ii) Ionic bond
(iii) Covalent bond
(iv) Covalent bond

136. Predict the type of bonding in the following:
(i) Ammonia
(ii) Calcium oxide
(iii) Oxygen
(iv) Hydrogen chloride
(v) Water

Ans :

(i) Covalent bond
(ii) Ionic bond
(iii) Covalent bond
(iv) Covalent bond
(v) Covalent bond

137. What is chemical bonding? Write the types of chemical bonding.

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Ans :

The chemical bond is the force of attraction which holds the different or the same particles together in a molecule.

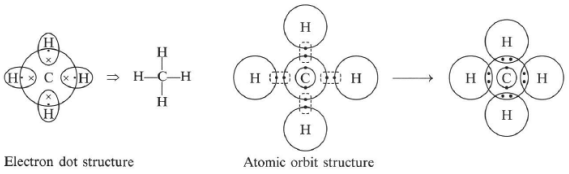
On the basis of the above two categories, the chemical bonds are classified as follows:

(i) By the transference of electrons: Ionic or Electrovalent bond.

(ii) By the mutual sharing of electrons: Covalent bond.

138. Explain the bonding in methane molecule using both electron dot structure and atomic orbit structure.

Ans :



139. There are three elements E, F and G with atomic numbers 19, 8 and 17 respectively.

(i) Classify the elements as metals and non-metals.

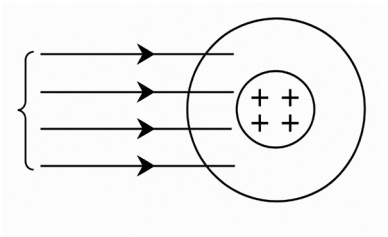
(ii) Give the molecular formula of the compound formed between E and G and state the type of chemical bond in this compound.

Ans :

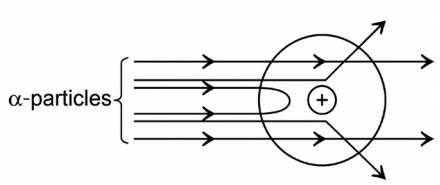
(i) Non-metal — F, G
Metal — E

(ii) EG, ionic bond.

140. Complete the ray diagram-



Ans :



141. Name the scientists who discovered

(i) electron (ii) proton
(iii) neutron (iv) nucleus

Ans :

(i) J.J. Thomson
(ii) Goldstein
(iii) Chadwick
(iv) Rutherford

142. How many electrons can be accomodated in the following named shells?

(i) K-shell (ii) L-shell
(iii) M-shell (iv) N-shell.

Ans :

The maximum electrons that can be accommodated in each shell is $2n^2$ where n = number of shells.

(i) K-shell $n = 1$ $2 \times 1 \times 1 = 2$ electrons

(ii) L-shell $n = 2$ $2 \times 2 \times 2 = 8$ electrons

(iii) M-shell $n = 3$ $2 \times 3 \times 3 = 18$ electrons

(iv) N-shell $n = 4$ $2 \times 4 \times 4 = 32$ electrons

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143. Give differences between atom and ion.

Ans :

The difference between

	Atom		**Ion**
(i)	It is electrically neutral.	(i)	It is electrically charged particle.
(ii)	The valence shell is incomplete except inert gases.	(ii)	The valence shell has complete octet or duplet.
(iii)	Atoms may or may not exist independently.	(iii)	Ions exist independently.

Study the table given below and answer the following questions:

Element	**Mass number**	**Atomic number**
A	1	1
B	14	7
C	40	20
D	32	16
E	20	10

(i) Identify an element having five valence electrons.
(ii) Identify an element having no neutron.
(iii) Identify an element exhibiting +2 valency.
(iv) Identify an element having zero valency.
(v) Identify an element exhibiting –2 valency.

Ans :

(i) B (ii) A (iii) C (iv) E (v) D

144. Write the characteristics of major subatomic particles of an atom.

Ans :

Particle	Symbol	Charge	Mass (amu)
Electron	${}_{-1}^{0}e$	–1 or -1.6×10^{-19} C	$\frac{1}{1837}$ of hydrogen atom (Negligible)
Proton	${}_{+1}^{1}p$	+1 or $+1.6 \times 10^{-19}$ C	1.008 amu
Neutron	${}_{0}^{1}n$	Zero	1.009 amu

145. How will you calculate the number of neutrons in an atom? Give one example.

Ans :

Number of neutrons = Atomic mass — Atomic number (Number of protons)

or n = A — Z

For example, an atom of magnesium having atomic mass 24 and atomic number 12 is represented as ${}_{12}^{24}\text{Mg}$
Number of neutrons in Mg atom = 24 – 12 = 12.

146. An element is represented as ${}_{20}^{40}\text{X}$. Name the cell which has valence electrons and the number of valence electrons in it.

Ans :

Element	At. No.	Electronic Configuration
X	20	2, 8, 8, 2 - V.E.
		K L M N

Valence shell = N

Number of valence electrons = 2.

147. Give reasons:
(i) An atom is electrically neutral.
(ii) Most of the alpha particles passed straight through gold foil in Rutherford experiment.
(iii) Very few alpha particles retraced their path.
(iv) Some alpha particles got deviated.

Ans :

(i) It is so because number of protons is equal to number of electrons; so, they destroy the charge of each other.
(ii) A lot of space in an atom is empty.
(iii) Total mass of the atom is centred at nucleus.
(iv) There is positive charge in the centre as like charges repel each other.

THREE MARKS QUESTIONS

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148. An atom has atomic number 13 and mass number 27.
(a) Number of protons
(b) Number of electrons
(c) Number of neutrons

Ans :

(a) Protons = 13
(b) Electrons = 13
(c) Neutrons = 27 – 13 = 14

149. State any three conclusions drawn by Rutherford from his Alpha Scattering Experiment.

Ans :

(i) Most of the atom is empty space.
(ii) Positive charge is concentrated in the nucleus.
(iii) The nucleus is very small and dense.

150. Why was Bohr's model considered better than Rutherford's model?

Ans :

(i) Bohr proposed fixed energy levels for electrons.
(ii) Electrons do not lose energy while revolving in these orbits.
(iii) It explained the stability of atoms.

151. An atom has the electronic configuration 2,8,7.
(a) Name the element.
(b) Number of valence electrons.
(c) State its valency.

Ans :

(a) Chlorine
(b) 7 valence electrons
(c) Valency = 1

152. Explain why sodium forms a positive ion.

Ans :

(i) Sodium has electronic configuration 2,8,1.
(ii) It loses one electron to attain stable configuration.
(iii) Hence it forms Na^+ ion.

153. Explain why chlorine forms a negative ion.

Ans :

(i) Chlorine has electronic configuration 2,8,7.
(ii) It gains one electron to complete its octet.
(iii) Hence it forms Cl^- ion.

154. Differentiate between proton, neutron and electron.

Ans :

(i) Proton has +1 charge and mass 1 amu.
(ii) Neutron has no charge and mass 1 amu.
(iii) Electron has –1 charge and negligible mass.

155. State three characteristics of isotopes.

Ans :

(i) They have the same atomic number.
(ii) They have different mass numbers.
(iii) They have similar chemical properties.

156. Write the electronic configuration of:
(a) Magnesium (12)
(b) Aluminium (13)
(c) Calcium (20)

Ans :

(a) Magnesium = 2,8,2
(b) Aluminium = 2,8,3
(c) Calcium = 2,8,8,2

157. Explain the octet rule.

Ans :

(i) Atoms try to attain eight electrons in the outermost shell.
(ii) This gives stable inert gas configuration.
(iii) Chemical bonding occurs to achieve this stability.

158. Differentiate between cation and anion.

Ans :

(i) Cation is positively charged.
(ii) Anion is negatively charged.
(iii) Cation is formed by loss of electrons, anion by gain of electrons.

159. Why are metals called reducing agents?

Ans :

(i) Metals lose electrons easily.
(ii) They donate electrons to other substances.
(iii) Therefore they bring about reduction.

160. Why are non-metals called oxidizing agents?

Ans :

(i) Non-metals gain electrons easily.
(ii) They accept electrons from other substances.
(iii) Therefore they bring about oxidation.

161. Explain the formation of magnesium chloride by ionic bonding.

Ans :

(i) Magnesium loses two electrons to form Mg^{2+}.
(ii) Two chlorine atoms gain one electron each to form $2Cl^-$.
(iii) Electrostatic attraction forms $MgCl_2$.

162. State three conditions necessary for the formation of an ionic bond.

Ans :

(i) One atom should lose electrons easily.
(ii) Another atom should gain electrons easily.
(iii) Transfer of electrons should result in stable configuration.

163. Explain the formation of hydrogen molecule (H_2).

Ans :

(i) Each hydrogen atom has one electron.
(ii) They share one pair of electrons.
(iii) A single covalent bond is formed.

164. Differentiate between ionic and covalent bonds.

Ans :

(i) Ionic bond is formed by transfer of electrons.
(ii) Covalent bond is formed by sharing of electrons.
(iii) Ionic bonds form ions whereas covalent bonds form molecules.

165. Explain why oxygen forms a double covalent bond.

Ans :

(i) Oxygen has six valence electrons.
(ii) It requires two more electrons for octet.

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(iii) Two pairs of electrons are shared between oxygen atoms.

166. Why does nitrogen form a triple covalent bond?

Ans :

(i) Nitrogen has five valence electrons.
(ii) Each nitrogen atom needs three electrons.
(iii) Three pairs of electrons are shared.

167. Differentiate between polar and non-polar covalent compounds with one example each.

Ans :

(i) Non-polar covalent compounds have little or no electronegativity difference; e.g., H_2.
(ii) Polar covalent compounds have appreciable electronegativity difference; e.g., HCl.
(iii) Polar molecules have unequal charge distribution, whereas non-polar molecules have uniform charge distribution.

168. What do the following symbols convey?
(i) 2H (ii) H_2

Ans :

(i) 2H : Two atoms of hydrogen.
(ii) H_2 : Two atoms of hydrogen combined chemically to form a molecule of hydrogen.

169. Three elements 'A', 'B' and 'C' have atomic numbers 4, 12 and 19 respectively.
(i) State the number of valence electrons in each element.
(ii) Do these elements have similar chemical properties? If yes, then why?
(iii) Do these elements belong to metals, non-metals or inert gases?

Ans :

(i)

Elements	Atomic no.	Electronic configuration				Valence electrons
		K	L	M	N	
A	4	2	2			2
B	12	2	8	2		2
C	19	2	8	8	1	1

(ii) Yes, they have the similar chemical properties as they are metals, i.e. they have 1 or 2 electrons in their valence shell.
(iii) These elements are metals.

170. Why Rutherford's model of atom was rejected, whereas the Bohr's model of atom was accepted?

Ans :

The Rutherford model of atom could not provide the stability to the nucleus. As according to the electromagnetic theory, a charged particle moving in a circular path continuously loses energy and hence will move towards the nucleus and fall into the nucleus following a spiral path, whereas Bohr gave the stability to the nucleus as he suggested that at the centre of atom, nucleus is present and electrons resolve out side the nucleus in a fixed path called orbit or shell without using or gaining energy.

171. What is the reason for fractional atomic masses of elements?

Ans :

Fractional atomic masses of the elements are because of the presence of Isotopes.
For example: Natural chlorine has two isotopes, ${}^{35}_{17}\text{Cl}$ and ${}^{37}_{17}\text{Cl}$ in the ratio of 3 : 1.
So, the atomic mass can be calculated as follows:
Atomic mass of 3 atoms of

$${}^{35}_{17}\text{Cl} = 3 \times 35 = 105 \text{ amu}$$

Atomic mass of 1 atom of

$${}^{37}_{17}\text{Cl} = 1 \times 37 = 37 \text{ amu}$$

Average atomic mass of chlorine

$$= \frac{3 \times 35 + 1 \times 37}{4} = \frac{105 + 37}{4}$$

$$= \frac{142}{4} = 35.5 \text{ amu}$$

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172. Complete the table given below:

Isotope	Symbolic representation	Protons	Electrons	Neutrons
Protium	${}^{1}_{1}\text{H}$	(i) ___	(ii) ___	(iii) __
Deuterium	${}^{2}_{1}\text{H}$	(iv) ___	(v) ___	(vi) __
Tritium	${}^{3}_{1}\text{H}$	(vii) ___	(viii) __	(ix) __

Ans :

Isotope	Symbolic representation	Protons	Electrons	Neutrons
Protium	${}^{1}_{1}\text{H}$	(i) 1	(ii) 1	(iii) 0
Deuterium	${}^{2}_{1}\text{H}$	(iv) 1	(v) 1	(vi) 1
Tritium	${}^{3}_{1}\text{H}$	(vii) 1	(viii) 1	(ix) 2

173. Elements A, B, C and D have atomic numbers 8, 9, 11 and 12 respectively.

(i) Write the electronic configurations of the elements.

(ii) Choose the electropositive and electronegative elements from the above elements.

Ans :

(i)

Elements	**Atomic no.**	**Electronic configuration**		
		K	**L**	**M**
A	8	2	6	
B	9	2	7	
C	11	2	8	1
D	12	2	8	2

(ii) Electropositive elements are C and D Electronegative elements are A and B.

174. Copy, complete the table and answer the questions that follows:

Element	Mass no.	Atomic no.	Protons	Neutrons	Electrons
A	40	20	—	—	—
B	35	—	—	18	—
C	40	—	—	22	—
D	27	13	—	—	—
E	12	6	—	—	—

(i) Give the electronic configurations of the elements from A to E.

(ii) Identify metals, non-metals and inert gases from the above elements (Do not identify the elements).

(iii) Identify the pair of isobars from the above element.

Ans :

Element	Mass no.	Atomic no.	Protons	Neutrons	Electrons
A	40	20	20	20	20
B	35	17	17	18	17
C	40	18	18	22	18
D	27	13	13	14	13
E	12	6	6	6	6

(i)

Elements	**Electronic Configuration**			
	K	**L**	**M**	**N**
A	2	8	8	2
B	2	8	7	
C	2	8	8	
D	2	8	3	
E	2	4		

(ii) A Metal
B Non-metal
C Insert gas
D Metal
E Non-Metal

(iii) A and C are the pair of isobars.

175. What were the drawbacks of Rutherford's model of atom.

Ans :

Drawbacks of Rutherford's Model of the Atom

1. Could not explain the stability of the atom : Rutherford said that electrons revolve around the nucleus in circular orbits. A moving electron should continuously lose energy and slow down. It should eventually fall into the nucleus, making the atom unstable. But in reality, atoms are perfectly stable, which Rutherford's model could not explain.
2. Could not explain the arrangement of electrons Rutherford's model did not give any information about how electrons are arranged around the nucleus. It also did not tell us how many electrons can be present in each orbit.
3. Could not explain the line spectrum of elements If electrons keep losing energy continuously, they should give out a continuous spectrum of light. But elements like hydrogen give a line spectrum, meaning only certain specific colours or wavelengths of light are emitted. Rutherford's model completely failed to explain this observation.

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FOUR MARKS QUESTIONS

176. An atom has atomic number 17 and mass number 35.
(a) Number of protons
(b) Number of electrons
(c) Number of neutrons
(d) Electronic configuration

Ans :

(a) Protons = 17
(b) Electrons = 17
(c) Neutrons = 35 – 17 = 18
(d) Electronic configuration = 2,8,7

177. Explain Rutherford's Alpha Scattering Experiment and state four conclusions drawn from it.

Ans :

(i) Most alpha particles passed straight through the gold foil.
(ii) Some were deflected through small angles.
(iii) Very few were deflected back.
(iv) Hence, the atom is mostly empty space and contains a small, dense, positively charged nucleus.

178. State four postulates of Bohr's Atomic Model.

Ans :

(i) Electrons revolve around the nucleus in fixed orbits.
(ii) These orbits are called shells or energy levels.
(iii) Electrons do not lose energy while revolving in a fixed orbit.
(iv) Energy is absorbed or emitted only when electrons jump between shells.

179. Differentiate between Electron, Proton and Neutron.

Ans :

Property	Electron	Proton	Neutron
Charge	–1	+1	0
Position	Outside nucleus	Inside nucleus	Inside nucleus
Mass	Negligible	1 amu	1 amu
Discoverer	J.J. Thomson	Goldstein	Chadwick

180. An element has atomic number 20.
(a) Write its electronic configuration.
(b) Number of valence electrons.
(c) State its valency.
(d) Name the element.

Ans :

(a) 2,8,8,2
(b) 2 valence electrons
(c) Valency = 2
(d) Calcium

181. Explain why isotopes have similar chemical properties but different physical properties.

Ans :

(i) Isotopes have the same atomic number.
(ii) Therefore they have the same electronic configuration.
(iii) Hence they show similar chemical properties.
(iv) Different mass numbers cause different physical properties.

182. Explain how chlorine acquires stable configuration during ion formation.

Ans :

(i) Chlorine has electronic configuration 2,8,7.
(ii) It requires one electron to complete its octet.
(iii) It gains one electron.
(iv) It forms chloride ion (Cl^-) with configuration 2,8,8.

183. Explain the formation of sodium chloride by ionic bonding.

Ans :

(i) Sodium loses one electron to form Na^+.
(ii) Chlorine gains one electron to form Cl^-.
(iii) Oppositely charged ions attract each other.
(iv) Sodium chloride is formed by electrostatic attraction.

184. State four characteristics of ionic compounds.

Ans :

(i) Formed by transfer of electrons.
(ii) Consist of cations and anions.
(iii) Usually formed between metals and non-metals.
(iv) Held together by strong electrostatic forces.

185. Explain the formation of magnesium chloride ($MgCl_2$) using ionic bonding.

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(ii) When more elements were discovered like He, Ne etc., they could not be accommodated in this table.

4. GROUPS AND PERIODS:

In periodic table, the vertical lines are called groups and the horizontal lines are called periods.

4.1 Groups

The vertical columns in the periodic table are called groups. There are a total of 18 groups in the modern periodic table. The elements present in the same group have similar chemical properties because they have the same number of valence electrons in their outermost shell. The group number of an element indicates the number of valence electrons present in its atom. As we move down a group, the atomic size increases due to the addition of a new shell in each successive element.

4.2 Periods

The horizontal rows in the periodic table are called periods. There are a total of 7 periods in the modern periodic table. The elements present in the same period have the same number of shells but different number of valence electrons. As we move across a period from left to right, the atomic number increases by one unit and the properties of the elements change gradually from metallic to non-metallic in nature.

4.3 Relationship between Groups and Periods

The position of an element in the periodic table is determined by its group number and period number. The group number indicates the number of valence electrons, whereas the period number indicates the number of shells present in the atom of that element. Together, the group and period of an element give a complete idea about its electronic configuration, chemical properties and its nature whether it is a metal, non-metal or metalloid.

5. MENDELEEV'S PERIODIC LAW

Mendeleev suggested the periodic law, i.e. the physical and the chemical properties of elements are the periodic functions of their atomic weights.
Anomalies of Mendeleev's Periodic Table: Mendeleev's periodic table had certain defects:

(i) Position of hydrogen: Hydrogen had a controversial position, i.e. it was placed in two groups, group 1 (alkali metals) and group 17 (halogens).
(ii) Position of isotopes.
(iii) Position of transition elements.
(iv) Position of rare earth metals.

1. (i) When Mendeleev presented his periodic table, inert gases were not discovered. He easily placed these elements at the end of the table without disturbing the table.
(ii) The elements which were discovered later could be easily placed in the gaps provided in the table.

6. MODERN PERIODIC TABLE:

The most accepted form of periodic table is the long form of the periodic table. In 1913, Moseley modified the previous periodic law as it states that the physical and the chemical properties of the elements are the periodic functions of their atomic number. As Moseley found that the atomic number (i.e. the number of protons) is more fundamental property of an atom than its atomic weight.
On the basis of the modern periodic law proposed by Moseley, the long form or Modern or Bohr's periodic table was prepared, which consists of 18 vertical lines (groups) and 7 horizontal lines (periods).
In the long form of periodic table, the elements having same number of valence electrons are placed under the same vertical columns called groups.

7. CHARACTERISTICS OF MODERN PERIODIC TABLE

The different characteristics of the long form of the periodic table are given below:
(i) The highly metallic elements are placed on the left hand side of the periodic table.
(ii) The highly non-metallic elements are placed on the right hand side of the periodic table.
(iii) The transition elements are accommodated between metals and non-metals.
(iv) The noble gases are placed in group 18.
(v) The elements present in the left and right side of the vertical columns are called normal elements or representative elements. The elements having complete penultimate shells are called normal elements or the representative elements.

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(ii) The outermost shell of an atom cannot have more than eight electrons, even though it may have the capacity to hold more and hence the penultimate shell, i.e. second last shell cannot have more than eighteen electrons.
(iii) The new shell begins as soon as the outermost shell attains 8 electrons.

192. An element 'X' is represented as $^{35}_{17}X$.
(i) What is the atomic number and mass number of 'X'?
(ii) How many protons, neutrons and electrons are there in element 'X'?
(iii) Give the electronic configuration of element 'X'.
(iv) How many valence electrons are present in element 'X'.
(v) Identify element 'X'. What is its actual mass number? Give reason for your answer.

Ans :

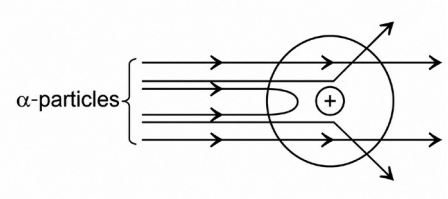
(i) Atomic number = 17, Mass number = 35
(ii) Proton = 17, Electron = 17, Neutron = 18
(iii) 2, 8, 7
(iv) 7
(v) X = Chlorine, 35.5
(A) chlorine is a mixture of 2 isotopes $_{17}C^{35}$ and $_{17}Cl^{37}$ in the ratio of 3 : 1 respectively. Thus,
Average atomic mass

$$= \frac{3 \times 35 + 1 \times 37}{4} = 35.5 \text{ amu.}$$

193. Explain Rutherford's experiment for the discovery of nucleus. What conclusions were drawn from the experiment?

Ans :

Rutherford took a gold foil and scattered a-particle on it.
He found that:
1. Most of the particles passed straight through the foil.
2. Some particles were deflected through small angles.
3. Some particles bounced back.



From this observations, he concluded that:
1. Most of the space inside the atom is empty because most of the a-particles passed straight through the gold foil.
2. There is a positive charge at the centre of the atom called the nucleus because a-particles having positive charge get deflected from their path as they are repelled by the same charge.
3. Total mass of the atom is centred in the nucleus as a-particles bounced back after striking the foil

194. How does the modern atomic theory contradict and correlate with Dalton's atomic theory?

Ans :

	Dalton's atomic theory		**Modern atomic theory**
(i)	According to Dalton, matter consists of small indivisible particles called atoms.	(i)	An atom is divisible as it consists of electron, proton and neutrons.
(ii)	Atom of the same element are identical.	(ii)	Atoms have isotopes to some atoms of an element have different atomic weight.
(iii)	Atoms of different elements are different in all respect.	(iii)	Atoms of different element are similar in some respect. e.g. atoms of argan and calcium have same atomic mass.
(iv)	Atoms combine in small whole numbers to form compound.	(iv)	Atoms of organic compound do not combine in small whole number ratio. They are highly complex.

Correlation

Atom is the smallest particles which takes part in a chemical reaction.

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(c) 1. The outermost orbit or shell can have a maximum of 8 electrons, known as an octet.
2. The penultimate shell (next inner to the outermost) can have a maximum of 18 electrons if permissible by the $2n^2$ rule.

201. Sunita received two unknown solid samples, labelled Substance X and Substance Y, during her practical examination. She tested Substance X and found that it was a highly volatile liquid that completely failed to conduct electricity when dissolved in water. Substance Y, on the other hand, was a hard, crystalline solid with a very high melting point. When Sunita melted Substance Y over a strong burner, the resulting molten liquid conducted electricity efficiently. She concluded that Substance X contained molecules formed by sharing electrons, whereas Substance Y consisted of oppositely charged ions.

(a) Give two reasons why Substance X exists as a volatile liquid and fails to conduct electricity.

(b) Give two reasons why Substance Y is a hard crystalline solid and conducts electricity in the molten state.

Ans :

(a) 1. Covalent compounds exist as volatile liquids due to weak intermolecular forces of attraction.
2. They are poor conductors of electricity because they lack freely moving charged ions in their dissolved state.

(b) 1. Ionic compounds are hard crystalline solids due to strong electrostatic forces of attraction between oppositely charged ions.
2. They conduct electricity when molten because the heat breaks these forces, allowing the ions freedom of movement.

202. Vikram was drawing electron dot structures for different hydrogen-containing compounds in his chemistry notebook. He first carefully drew a methane molecule, noting that the central carbon atom shares four electron pairs equally with four surrounding hydrogen atoms. He then sketched an ammonia molecule, where a central nitrogen atom combines with exactly three hydrogen atoms to complete its octet. Vikram observed that both molecules successfully attain stable noble gas configurations without any complete transfer of electrons. However, his textbook mentioned that the shared electron pairs in one of these compounds might not remain perfectly equidistant from both combining nuclei. This unequal distribution leads to the development of partial positive and negative charges within the molecule.

(a) Name the type of chemical bond formed by the mutual sharing of electrons between atoms.

(b) State the total number of single covalent bonds present in one molecule of methane.

(c) Identify the inert gas whose stable electronic configuration is attained by the nitrogen atom in an ammonia molecule.

(d) State whether an ammonia molecule is considered a polar or non-polar covalent compound.

Ans :

(a) A covalent (or molecular) bond is formed by the mutual sharing of one or more pairs of electrons between two combining atoms.

(b) One molecule of methane contains exactly four single covalent bonds.

(c) The nitrogen atom in ammonia attains the stable electronic configuration of the nearest noble gas, Neon (Ne).

(d) An ammonia molecule is considered a polar covalent compound.

203. Neha was analyzing a data table of various elements provided by her instructor. She found two distinct elemental atoms: an argon atom containing 18 protons and a potassium atom containing 19 protons. Despite the difference in their proton counts, she calculated that both atoms possess exactly the same mass number of 40. Neha realised that the total count of heavy particles inside their central nuclei must be identical. She wondered how elements with completely unique physical and chemical characteristics could share this specific numerical property.

(a) Calculate the number of neutrons present in the given argon atom.

(b) Calculate the number of neutrons present in the given potassium atom.

(c) Name the specific collective term used for the protons and neutrons present in the nucleus of an atom.

(d) Identify the specific scientific term used to describe distinct elemental atoms that have different atomic numbers but the same mass number.

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198. Aarav was conducting research on the halogen group elements for his chemistry project. He noticed that a naturally occurring sample of chlorine gas collected in the laboratory consistently exhibits a relative atomic mass of 35.5. He found this puzzling because atomic masses are usually whole numbers based on nucleon count. His teacher explained that chlorine exists in nature as a mixture of two distinct atomic forms having mass numbers 35 and 37. Aarav also discovered that similar atomic variants of other elements have highly specialised uses. For example, he read about a specific radioactive form of cobalt that is widely utilised in modern hospitals.

(a) Calculate the average atomic mass of chlorine if the naturally occurring atomic forms of mass 35 and 37 are present in a 3:1 ratio.

(b) State two physical properties that differ between these two atomic forms of chlorine.

(c) State the medical application of the radioactive form of cobalt mentioned in the scenario.

Ans :

(a) Average atomic mass

$$= \frac{\text{Mass}_1 \times \text{Ratio}_1) + (\text{Mass}_2 \times \text{Ratio}_2)}{\text{Total Ratio}}$$

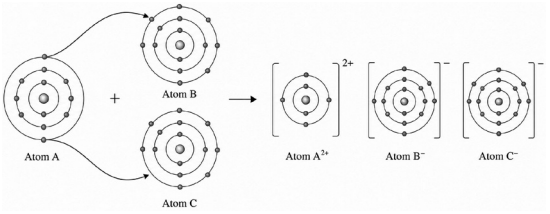
$$= \frac{(35 \times 3) + (37 + 1)}{4}$$

$$= \frac{105 + 37}{4} = \frac{142}{4} = 35.5$$

(b) 1. The two forms differ in their physical constants like density.
2. They also differ in their boiling points because heavier masses result in higher boiling points.

(c) The radioactive isotope of cobalt (Co-60) is used in radiotherapy for the successful treatment of cancer and other diseases.

199. Siddharth was practicing the orbital representation of chemical combinations for his upcoming test. He analysed the diagram below, which illustrates how a metallic atom interacts with two non-metallic atoms to achieve stable octets.



(a) Identify the metallic atom and the non-metallic atoms participating in the chemical combination shown in the diagram.

(b) State the final electronic configuration of the newly formed metallic cation and the non-metallic anions shown on the product side of the diagram.

Ans :

(a) 1. The metallic atom with a 2, 8, 2 configuration is Magnesium (Mg).
2. The non-metallic atoms with a 2, 8, 7 configuration are Chlorine (Cl).

(b) 1. The final electronic configuration of the newly formed magnesium cation is 2, 8.
2. The final electronic configuration of the two chloride anions is 2, 8, 8.

200. Meera was tasked with writing the electronic distribution for various metallic elements on the chalkboard. She started with a calcium atom, which contains 20 electrons in total. She initially thought the third shell could hold up to 18 electrons according to a specific mathematical formula, leading her to write an incorrect arrangement of 2, 8, 10. Her classmate pointed out that the outermost shell cannot hold more than 8 electrons, meaning the remaining two electrons must enter the next higher shell. Meera then corrected her work to reflect the stepwise filling of energy levels.

(a) Calculate the maximum capacity of electrons in the third shell (M-shell) using the mathematical formula mentioned.

(b) Write the correct electronic configuration of a calcium atom.

(c) State two rules proposed independently by Bohr and Bury in 1921 regarding the maximum number of electrons in the outermost and penultimate shells.

Ans :

(a) Maximum number of electrons

$= 2n^2 2\times(3)^2\, 2\times 9 = 18$ electrons.

(b) The correct electronic configuration of a calcium atom is 2, 8, 8, 2.

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(c) Name the exact type of chemical bond formed by the mutual sharing of two pairs of electrons.

(d) State whether the resulting molecule is polar or non-polar.

Ans :

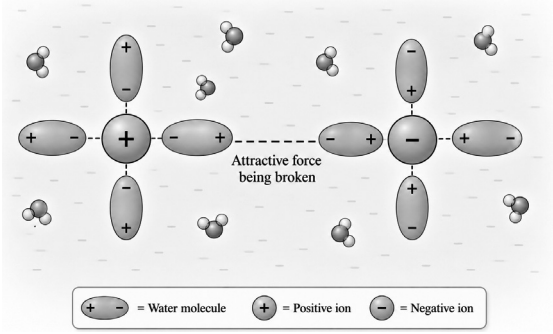
(a) The atomic structures represent atoms of the element Oxygen (O_2).

(b) There are two shared pairs of electrons in the overlapping central region.

(c) The mutual sharing of two pairs of electrons results in a double covalent bond.

(d) The resulting molecule is a perfectly non-polar covalent compound because the atoms are identical.

207. Priya was investigating why certain solid crystalline substances dissolve readily in water. She looked at the diagram below, which illustrates the microscopic interactions between the solvent molecules and the charged particles of the solid.



(a) Identify the specific oval-shaped structures with positive and negative ends shown surrounding the central particles.

(b) Name the positively charged central particle and the negatively charged central particle shown in the diagram.

(c) State the reason why the oval structures orient themselves differently around the positive and negative central particles.

(d) State what happens to the electrical conductivity of the solid crystalline substance once these interactions completely separate its constituent particles in the liquid.

Ans :

(a) The oval-shaped structures are polar water molecules, also referred to as water dipoles.

(b) The positively charged particle is a sodium cation (Na^+) and the negatively charged particle is a chloride anion (Cl^-).

(c) The negative end of the water dipole attracts the positive Na^+ ion, and the positive end attracts the negative Cl^- ion due to electrostatic forces.

(d) Once dissolved, the separated ions acquire freedom of movement, allowing the aqueous solution to conduct electricity.

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Ans :

(a) Number of neutrons (n)

= Mass number (a) - Atomic number (Z)

= 40 - 18 = 22 neutrons.

(b) Number of neutrons (n)

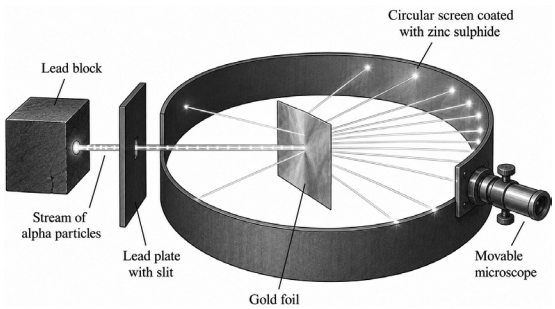
= Mass number (a) - Atomic number (Z)

= 40 - 19 = 21 neutrons.

(c) Protons and neutrons present in the nucleus of the atom are collectively called nucleons.

(d) Distinct elemental atoms with different atomic numbers but the same mass number are called isobars.

204. Karthik was reviewing an early 20th-century experiment that fundamentally changed the understanding of atomic structure. He examined the diagram below showing the paths of highly energetic particles directed at a thin metal target inside an evacuated chamber.



(a) Identify the specific positively charged particles emitted from the source block in this experiment.

(b) State the atomic part that was discovered as a direct result of the few particles deflecting at wide angles or bouncing back.

(c) State the two conclusions drawn regarding the nature and size of the positively charged body inside the atom based on the deflected particles.

Ans :

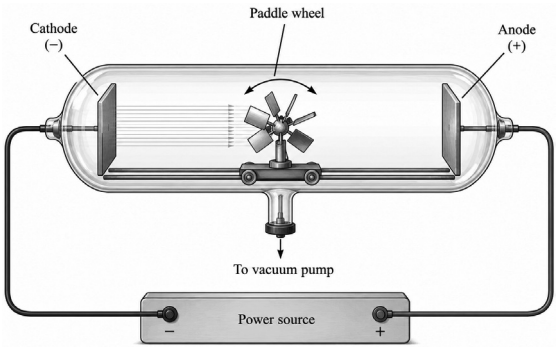
(a) The positively charged particles emitted from the source block are alpha (α) particles.

(b) The nucleus of the atom was discovered as a result of these wide-angle deflections.

(c) 1. The heavy, positively charged body inside the atom must be very small in volume.

2. The entire mass of the atom is concentrated within this positively charged central body.

205. Anjali observed a demonstration involving an evacuated glass tube connected to a high voltage generator. She noticed the mechanical interaction depicted in the diagram below when invisible rays travelled from the negative terminal to the positive terminal.



(a) Name the invisible rays originating from the left metal plate.

(b) State the specific property of these rays demonstrated by the mechanical motion of the paddle wheel, and state the electrical charge carried by these rays.

(c) Identify the subatomic particle that constitutes these rays.

Ans :

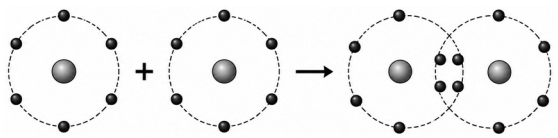
(a) The invisible rays emanating from the cathode are called cathode rays.

(b) 1. The mechanical motion of the paddle wheel demonstrates that the rays are made of material particles.

2. These rays are found to carry a negative charge.

(c) The subatomic particle that constitutes these negatively charged rays is the electron.

206. Arjun was learning how non-metallic atoms achieve stable electronic configurations without transferring electrons. He closely studied the diagram below, which demonstrates the mutual sharing of valence electrons between two identical atoms.



(a) Identify the specific gaseous element whose atoms are represented in the diagram.

(b) State the total number of shared pairs of electrons in the overlapping region.

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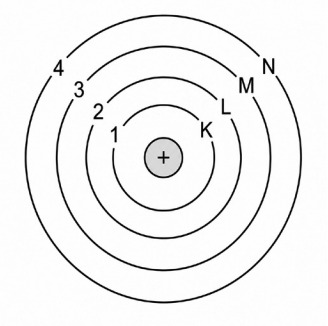
195. State Bohr's model of structure of atom.

Ans :

Neil Bohr gave an explanation to the stability of an atom mentioned as follows:

1. In an atom, electrons revolve in a fixed path called orbit or shell. Each orbit or shell has a definite amount of energy, so, it is also called energy level.
2. The shell or energy levels are designated as 1, 2, 3, 4, ... or K, L, M, N ... Starting from the innermost.



3. The electrons revolving in an orbit neither lose nor gains energy. They absorb energy when jump from inner shell to outer shell and vice versa.
4. The number of electrons that can be accommodated in different orbit is fixed. The first shell can occupy maximum 2 electrons, 2nd shell can occupy 8 electrons, third can occupy 18 electrons and so on.

CASE BASED QUEATIONS

196. Rohan was studying the historical progression of atomic theories in his school library. He read a book from 1808 stating that atoms can neither be created nor destroyed and cannot be further divided into still smaller particles. However, Rohan knew from recent lessons that atoms are actually composed of subatomic particles. He learned that while protons and electrons were discovered relatively early, a third fundamental particle was found much later in 1932. This delayed discovery occurred when scientists observed highly penetrating, neutral radiation emitted upon bombarding beryllium with alpha particles.

(a) State two main postulates of the 1808 atomic theory that were later disproved by the discovery of subatomic particles.

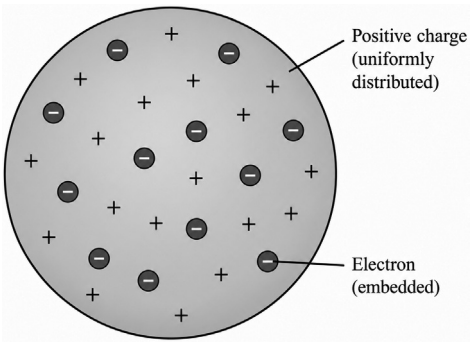
(b) Identify the neutral subatomic particle discovered in 1932 and state its absolute mass in grams.

Ans :

(a) 1. All forms of matter consist of very small and indivisible particles called atoms.
2. An atom cannot be further divided into still smaller particles.

(b) 1. The neutral subatomic particle discovered in 1932 is the neutron.
2. The absolute mass of a neutron is 1.6749 $\times 10^{-24}$ g (or 1.675 $\times 10^{-24}$ g).

197. Divya was reading a historical text about early attempts to describe the internal layout of an atom. She encountered the diagram below, which proposed a specific arrangement of electrical charges that was eventually rejected.



(a) State the specific name given to the dark circles containing minus signs, and state the nature of the continuous background sphere according to this historical model.

(b) State two main drawbacks of this specific atomic model that led to its rejection by later scientists.

Ans :

(a) 1. The dark circles containing minus signs are electrons.
2. The continuous background is a sphere of uniform positive electricity.

(b) 1. It failed to provide an explanation for Rutherford's alpha-ray scattering experiment.
2. It failed to explain the overall stability of the atom and did not discuss the nucleus.

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CHAPTER 5

The Periodic Table

SUMMARY

1. PERIODIC TABLE

The table in which the elements are arranged in the increasing order of their atomic number is called the periodic table.

1.1 Periodic Properties

The similar properties which recur after a regular interval are called the periodic properties. Several attempts were made to classify the elements so as to make their study simple and systematic.

2. DOBEREINER'S TRIADS

J.W. Dobereiner arranged the elements in the group of three called triads. According to this, the chemically similar elements were arranged in the increasing order of their atomic weights in the group of three to make a triad. It was noted that the atomic weight of the middle element present in a triad is the mean of the other two elements.

(i) Triad of alkali metals – lLithium, sodium and potassium have atomic weights 7, 23 and 39 respectively. By taking the arithmetic mean of lithium and potassium we get the atomic weight of sodium, i.e., i.e. $\frac{7+39}{2} = \frac{46}{2} = 23$.

(ii) Triad of halogens – chlorine, bromine and iodine have atomic weights 35.5, 80.4 and 126.5 respectively. By taking the arithmetic mean of chlorine and iodine, we get the atomic weight of bromine, i.e. $\frac{35.5+126.5}{2} = 81$

(iii) Triad of alkaline earth metals – calcium, strontium and barium have atomic weights 40, 88 and 137 respectively. By taking the arithmetic mean of calcium and barium, we get the atomic weight of strontium, i.e. $\frac{40+137}{2} = 88.5$.

This classification was not accepted as many elements could not be grouped in triads.

For very low mass or for very high mass elements, the law was not holding good, e.g. F, Cl and Br. Atomic mass of Cl is not the arithmetic mean of atomic masses of F and Br.

2.1 Limitations of Dobereiner's Triads

This classification was not accepted as many elements could not be grouped in triads. For very low mass or for very high mass elements, the law was not holding good, e.g. F, Cl and Br. Atomic mass of Cl is not the arithmetic mean of atomic masses of F and Br.

3. NEWLAND'S LAW OF OCTAVES

Newland arranged the elements in the increasing order of their atomic weights. He suggested that the properties of the elements recur after a regular interval after every seven elements, just like the repetition of musical notes.

Newland arranged the elements known at that time in the following manner:

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca					

3.1 Failure of Newland's law of octaves:

Although Newlands' Law of Octaves was an important step in the development of the periodic table, it had certain serious limitations and drawbacks that led to its rejection. The main reasons for the failure of Newlands' Law of Octaves are as follows:

(i) It was not valid for elements that had atomic masses higher than calcium.

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Ans :

(i) Magnesium has electronic configuration 2,8,2.
(ii) It loses two electrons to form Mg^{2+}.
(iii) Two chlorine atoms gain one electron each to form $2Cl^{-}$.
(iv) Electrostatic attraction forms $MgCl_2$.

186. Explain the formation of hydrogen molecule (H_2) using covalent bonding.

Ans :

(i) Each hydrogen atom contains one electron.
(ii) Each requires one more electron for stable duplet configuration.
(iii) Both atoms share one pair of electrons.
(iv) A single covalent bond is formed.

187. Explain the formation of oxygen molecule (O_2).

Ans :

(i) Each oxygen atom has six valence electrons.
(ii) Each atom requires two electrons to complete octet.
(iii) Two pairs of electrons are shared.
(iv) A double covalent bond is formed.

188. Explain the formation of nitrogen molecule (N_2).

Ans :

(i) Nitrogen has five valence electrons.
(ii) Each nitrogen atom requires three electrons.
(iii) Three pairs of electrons are shared.
(iv) A triple covalent bond is formed.

189. Differentiate between Ionic Bond and Covalent Bond.

Ans :

Ionic Bond	**Covalent Bond**
Formed by transfer of electrons	Formed by sharing of electrons
Forms ions	Forms molecules
Usually between metal and non-metal	Usually between non-metals
Example: NaCl	Example: H_2O

190. Explain the formation of water (H_2O) molecule using covalent bonding.

Ans :

(i) Oxygen has six valence electrons and requires two more electrons.
(ii) Each hydrogen atom contributes one electron.
(iii) Oxygen shares one electron with each hydrogen atom.
(iv) Two single covalent bonds are formed, producing a stable H_2O molecule.

191. Identify metals, non-metals and inert gases from the following elements and give reasons in support of your answer.
Chlorine, Magnesium, Argon, Phosphorus, Potassium, Sulphur, Oxygen

Ans :

Element	Electronic configuration	Type of metal	Reason
Chlorine	2, 8, 7	Non-metal	As it has '7' electrons in its valence shell
Magnesium	2, 8, 2	Metal	As it has '2' electrons in its valence shell
Argon	2, 8, 8	Inert gas	As it has '8' electrons in its valence shell
Phosphorus	2, 8, 5	Non-metal	As it has '5' electrons in its valence shell
Potassium	2, 8, 8, 1	Metal	As it has '1' electron in its valence shell
Sulphur	2, 8, 6	Non-metal	As it has '6' electrons in its valence shell
Oxygen	2, 6	Non-metal	As it has '6' electrons in its valence shell

State Bohr-Bury's scheme of electronic configuration.

Ans :

The distribution of electrons in various energy levels is governed by Bohr-Bury scheme. According to this scheme, there are three important rules.

(i) Maximum number of electrons that can be accommodated in a shell is given by, $2n^2$ where n = number of shells or energy levels.

K-shell	$n = 1$	$2 \times 1 \times 1 = 2e^{-}$
L-shell	$n = 2$	$2 \times 2 \times 2 = 8e^{-}$
M-shell	$n = 3$	$2 \times 3 \times 3 = 18e^{-}$
N-shell	$n = 4$	$2 \times 4 \times 4 = 32e^{-}$

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(vi) Lanthanoids and Actinoids are placed outside the main body of the periodic table.
(vii) The seventh period is an incomplete period.

7.1 Group Names of Elements

The elements present in different groups are given specific names like

Group number	Name
1	Alkali metals
2	Alkaline earth metals
17	Halogens
18	Inert gases or Noble gases

7.2 Periods in the Periodic Table

In the periodic table, the horizontal rows are called periods.
(i) First period is the shortest period having only 2 elements.
(ii) Second period is a short period that consists of 8 elements.
(iii) Third period is also a short period that consists of 8 elements.
(iv) Fourth period is a long period which consists of 18 elements. Ten elements are of transition series and eight elements are the normal elements.
(v) Fifth period is also a long period that consists of 18 elements. Eight are normal elements or representative elements and ten are transition elements.
(vi) Sixth period is a very long period which consists of 32 elements. It includes eight normal or representative elements, ten transition elements and fourteen inner transition elements of lanthanoids series.
(vii) Seventh period is an incomplete period.

8. PROPERTIES OF METALS AND NON-METALS

The periodic table not only arranges elements in a systematic manner but also helps us understand the gradual change in their properties across periods and down the groups. The properties of metals and non-metals are closely related to their position in the periodic table and the number of electrons present in their valence shell. The important properties of metals and non-metals in relation to the periodic table are as follows:
1. As we move down the group, the basic character of oxides increases.
2. As we move across the period, the acidic character of oxides increases.
3. At the end of every period, there is the presence of an inert gas with octet configuration.
4. Inert gases have zero valency as they can neither lose electron nor they can gain electron as they have complete octet.
5. Metals have 1, 2 or 3 electrons in their valence shell.
6. Metals can easily lose their outermost 1, 2 or 3 electrons to complete their outermost octet hence they act as reducing agents.
7. Non-metals have 5, 6 or 7 electrons in their valence shell.
8. Non-metals can easily gain electrons to complete their outermost octet, hence they act as oxidizing agents.
9. Metals lose electrons to form positively charged particles called cations, whereas non-metals gain electrons to form negatively charged particles called anions.

8.1 Significance of the Long Form of Periodic Table

The long form of the periodic table gives a clear demarcation of different kinds of elements. The similar elements are placed together and their properties are discussed and studied separately.
1. Group 1 elements are called alkali metals because their hydroxides are soluble in water and form strong bases.
2. Group 2 elements are called alkaline earth metals because they occur in the earth in free state.
3. Group 17 elements are called halogens(salt producers).

The elements of group 18 or zero group are called inert gases or noble gases or rare gases as they have stable configuration following the octet rule.

8.2 Striking Features of Alkali Metals (Group 1)

Alkali metals are the elements present in Group 1 of the modern periodic table. They are called alkali metals because their hydroxides are soluble in water and form strong alkaline solutions. These metals are highly reactive and possess some very distinctive properties that set them apart from other groups of elements. The striking features of alkali metals (Group 1) are::
(i) Most electropositive in nature.

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(B) It arranged elements strictly by atomic number instead of atomic mass.
(C) It could not classify all the then-known elements into sets of triads.
(D) It combined elements exhibiting completely different chemical properties into single units.

Ans : (C)

The primary limitation of this early classification system was its inability to encompass every known chemical substance. Many existing elements simply could not be grouped into sets of three while maintaining the required mathematical relationship regarding their respective atomic masses.

8. The Modern Periodic Law resolved the issue of anomalous pairs found in Mendeléev's table. Using the data for Argon and Potassium, determine the correct ordering according to the Modern Periodic Law and the reason for it.

Element	Symbol	Atomic Mass (u)	Atomic Number
Argon	Ar	39.9	18
Potassium	K	39.1	19

(A) K before Ar, because its atomic mass is lower.
(B) Ar before K, because its atomic number is lower.
(C) K before Ar, because it is a metal.
(D) Ar before K, because it is a gas at room temperature.

Ans : (B)

The Modern Periodic Law states that properties of elements are a periodic function of their atomic numbers. As Argon has an atomic number of 18 and Potassium has an atomic number of 19, Argon is correctly placed before Potassium in the modern periodic table. This arrangement is independent of their atomic masses.

9. Consider the following statements regarding Newlands' Law of Octaves

I. Elements were arranged in increasing order of their atomic masses.
II. Every eighth element showed similarities in properties to the first element.
III. The law was applicable successfully to all known elements up to barium.
IV. Iron was placed far away from cobalt and nickel despite having similar properties.

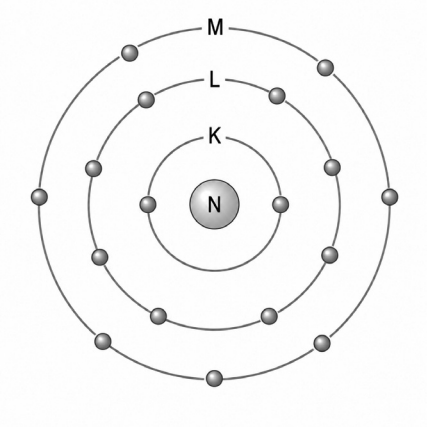
Which of the above statements are correct?

(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

This classification successfully arranged elements by increasing atomic mass, revealing periodic similarities resembling musical octaves. However, it only worked effectively up to calcium. A significant flaw was placing iron far from cobalt and nickel, ignoring their obvious chemical similarities completely.

10. The diagram shows a Bohr model of an atom. To which period of the Modern Periodic Table does this element belong?



(A) Period 2
(B) Period 3
(C) Period 7
(D) Period 8

Ans : (B)

The period number of an element in the Modern Periodic Table corresponds to the number of occupied electron shells in its atom. The atom in the diagram has electrons in three shells (K, L, and M). Therefore, the element belongs to the 3rd period of the periodic table.

11. According to Newlands' Law of Octaves, chemical and physical properties repeat periodically. Which of the following elements shows properties most similar to those of beryllium under this system?

(A) Lithium
(B) Magnesium
(C) Boron
(D) Silicon

Ans : (B)

In this system, arranging elements by increasing

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(A) Solids and Liquids
(B) Metals and Non-metals
(C) Active and Inert elements
(D) Representative and Transition elements

Ans : (B)

Lavoisier made one of the earliest attempts to systematically organise chemical substances by focusing on readily observable properties. He broadly grouped the available elements into metals and non-metals. This initial division served as a fundamental step toward understanding broader elemental relationships.

3. A chemistry student is attempting to validate Döbereiner's Law of Triads using the data provided. Which set of elements from the table correctly forms a Döbereiner's triad?

Set	Element 1 (Mass)	Element 2 (Mass)	Element 3 (Mass)
1	F(19.0)	Cl(35.5)	Br(79.9)
2	Li(6.9)	Na(23.0)	K(39.1)
3	N(14.0)	P(31.0)	As(74.9)
4	H(1.0)	Li(6.9)	Na(23.0)

(A) Set 1
(B) Set 2
(C) Set 3
(D) Set 4

Ans :(B)

According to Döbereiner's Law of Triads, the atomic mass of the middle element is the arithmetic mean of the other two. For Set 2, the mean of Li and K is $(6.9 + 39.1)/2 = 23.0$, which matches the atomic mass of Na. The other sets do not show this mathematical relationship accurately.

4. In Dobereiner's classification, elements were placed in groups of three. Which of the following correctly represents a valid Dobereiner triad based on similar chemical properties?
(A) Carbon, Nitrogen, Oxygen
(B) Lithium, Sodium, Potassium
(C) Fluorine, Chlorine, Bromine
(D) Magnesium, Calcium, Strontium

Ans : (B)

Lithium, sodium, and potassium constitute a valid triad because they exhibit similar chemical properties and valency. The atomic mass of sodium is exactly the arithmetic mean of the atomic masses of lithium and potassium, satisfying the central requirement of this classification.

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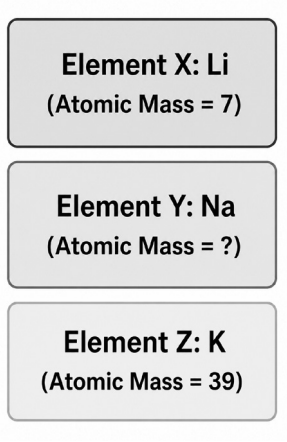
5. The diagram shows a triad of elements as proposed by Döbereiner. Based on the law of triads, what is the approximate atomic mass of element Y?



(A) 16
(B) 23
(C) 32
(D) 46

Ans :(B)

Döbereiner's Law of Triads states that the atomic mass of the middle element in a triad is the arithmetic mean of the other two. Therefore, the approximate atomic mass of Sodium (Na) is the average of Lithium (Li) and Potassium (K), which is $(7 + 39) / 2 = 23$.

6. A Dobereiner triad consists of calcium, strontium, and barium. The atomic mass of calcium is 40 and that of barium is 1What is the approximate atomic mass of strontium based on this law?
(A) 87.6
(B) 88.5
(C) 89.0
(D) 90.5

Ans : (B)

According to the principle of triads, the atomic mass of the middle element is the arithmetic average of the first and third elements. Adding forty and one hundred thirty-seven gives one hundred seventy-seven. Dividing this sum by two yields eighty-eight point five.

7. Despite offering an interesting perspective on atomic mass relationships, Dobereiner's Law of Triads was ultimately discarded. What was its primary drawback?
(A) It placed metals and non-metals in the exact same triad group.

(ii) Good reducing agents.
(iii) Valency is +1.
(iv) They have low ionization potential.
(v) They form metal halides.
(vi) Good conductors of heat andelectricity.
(vii) They have largest atomic size in their periods.
(viii) Due to their strong tendency to lose their valence electrons, they are highly reactive and react vigorously with air, dilute acids and cold water to liberate hydrogen. The reactivity increases on moving down the group.

	Alkali Metals
1.	Lithium (Li)
2.	Sodium (Na)
3.	Potassium (K)
4.	Rubindium (Rb)
5.	Cesium (Cs)
6.	Francium

8.3 Striking Features of Alkaline Earth Metals (Group 2) Properties

Striking features of alkaline earth metals (Group 2):
(i) Electropositive in nature.
(ii) Valency is +2.
(iii) Good conductors of heat and electricity.
(iv) They are usually solids.
(v) They form ionic bonds
(vi) They impart characteristic colours to the flame.

	Alkaline Earth Metals
1.	Beryllium (Be)
2.	Magnesium (Mg)
3.	Calcium (Ca)
4.	Strontium (Sr)
5.	Barium (Ba)
6.	Radium (Ra)

8.4 Striking Features of Halogens (Group 17)

The striking features of halogens (Group 17) are:
(i) Most electronegative in nature.
(ii) Good oxidising agents.
(iii) Valency is – 1.
(iv) They have high electron affinity.
(v) They undergo ionic bond formation with metals
(vi) Poor conductors of electricity.
(vii) They have smallest size in their period.
(viii) They do not react with dilute acids.

	Halogens
1.	Fluorine (F)
2.	Chlorine (Cl)
3.	Bromine (Br)
4.	Iodine (I)
5.	Astatine (At)

8.5 Striking Features of Zero Group (Group 18)

Striking features of zero group (Group 18) :
(i) They are called insert gases or noble gases due to stable electronic configuration.
(ii) They do not react under ordinary conditions.
(iii) They have high ionization energies and negligible electronegativities.

	Noble Gases
1.	Helium (He)
2.	Neon (Ne)
3.	Argon (Ar)
4.	Krypton (Kr)
5.	Xenon (Xe)
6.	Radon (Rn)

OBJECTIVE QUESTIONS

1. An alkaline earth metal is
(a) Potassium (b) Calcium
(c) Lead (d) Copper

Ans :
(b) Calcium
Calcium (Ca) belongs to Group 2 of the modern periodic table and is therefore classified as an alkaline earth metal. Potassium belongs to Group 1 (alkali metals), while lead and copper are transition metals. Alkaline earth metals have valency of +2 and are electropositive in nature.

2. Lavoisier made one of the earliest known attempts to classify the chemical elements into distinct categories. Which of the following best represents the classification system proposed by him?

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atomic mass results in every eighth element exhibiting similar characteristics. Starting from beryllium as the first element, magnesium appears exactly eighth in the sequence. Therefore, they share identical chemical and physical elemental properties.

12. One of the primary bases of Mendeléev's Periodic Table was the arrangement of elements in order of increasing atomic mass. However, this led to certain anomalies where this rule had to be inverted to maintain the similarity in properties within a group. Which pair in the table represents such an anomalous pair?

Pair	Element	Atomic Number	Atomic Mass (u)
1	Sodium (Na)	11	23.0
	Magnesium (Mg)	12	24.3
2	Argon (Ar)	18	39.9
	Potassium (K)	19	39.1
3	Chlorine (Cl)	17	35.5
	Argon (Ar)	18	39.9
4	Silicon (Si)	14	28.1
	Phosphorus (P)	15	31.0

(A) Pair 1
(B) Pair 2
(C) Pair 3
(D) Pair 4

Ans : (B)

(A) anomalous pair in Mendeléev's table is one where an element with a higher atomic mass is placed before an element with a lower atomic mass. In Pair 2, Argon (atomic mass 39.9 u) is placed before Potassium (atomic mass 39.1 u) to keep Potassium with other alkali metals. This violates the strict order of increasing atomic mass.

13. What were the two main guiding factors that led Dmitri Mendeleev to create his periodic table?
(A) Increasing atomic number and grouping elements with different physical states
(B) Increasing atomic weight and grouping elements with similar chemical properties
(C) Increasing atomic volume and grouping elements by their electrical conductivity
(D) Increasing atomic radius and grouping elements strictly by their valency

Ans : (B)

The tabular arrangement was systematically formulated using two primary principles. Elements were placed in the sequential order of their increasing atomic weights. Additionally, substances exhibiting similar chemical characteristics were deliberately grouped together to ensure structural consistency and logical scientific progression.

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14. Mendeleev's periodic table featured several intentionally vacant spaces. What was the primary scientific justification for leaving these specific gaps?
(A) To strictly separate highly reactive metals from non-metals
(B) To easily accommodate newly discovered noble and inert gases
(C) To confidently predict the existence and properties of undiscovered elements
(D) To temporarily adjust elemental positions possessing doubtful atomic weights

Ans : (C)

Blank spaces were intentionally left in the tabular arrangement to account for substances that had not yet been identified. This visionary approach allowed for accurate predictions regarding the physical and chemical characteristics of these missing elements before their actual discovery.

15. Using his periodic table, Mendeleev confidently predicted the existence of a missing element he named Eka-aluminium. Which subsequently discovered element eventually replaced Eka-aluminium?
(A) Germanium
(B) Gallium
(C) Scandium
(D) Indium

Ans : (B)

Eka-aluminium was a placeholder name derived from Sanskrit to indicate its position below aluminium. When a new chemical substance was later discovered possessing the exact atomic weight and physical properties predicted earlier, it was officially named gallium and placed accordingly.

16. Read the assertion and reason carefully and select the correct option.
Assertion (A) : Isotopes of a single element were not assigned separate places in Mendeleev's periodic table.
Reason (R) : Isotopes of an element have similar chemical properties but different atomic masses.
(A) Both A and R are true and R is the correct of A

Ans : (B)

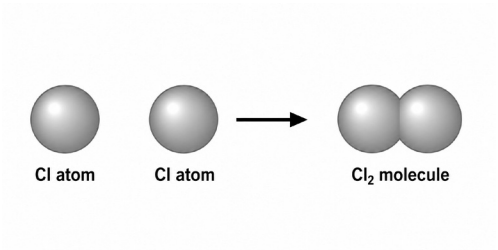
These highly active substances consistently lose their solitary outer electron to form stable positive ions. Because they readily undergo vigorous chemical reactions with moisture and atmospheric gases, they never exist freely in the natural environment and require careful artificial storage.

36. The third period elements Na, Mg, Al, Si, P, S, and Cl perfectly summarise the properties of their respective vertical groups. What is the specific formal term used to classify these particular elements?
(A) Bridge elements
(B) Noble elements
(C) Typical elements
(D) Inner transition elements

Ans : (C)

These specific chemical substances serve as perfect structural models for the vertical columns they occupy. Because they clearly exhibit all the characteristic chemical and physical traits expected within their distinct families, scientists formally identify them as the standard representative members.

37. The diagram shows the formation of a molecule of an element from Group What does this representation indicate about the nature of halogens at room temperature?



(A) They exist as single, independent atoms.
(B) They are monoatomic gases.
(C) They form diatomic molecules.
(D) They readily lose electrons to form cations.

Ans : (C)

Halogens (Group 17 elements) are highly reactive non-metals that need one more electron to achieve a stable noble gas configuration. They achieve this by sharing an electron with another halogen atom, forming a stable, covalently bonded diatomic molecule. Examples include F_2, Cl_2, Br_2, and I_2, as depicted for chlorine (Cl_2).

38. Which of the following is NOT considered a valid characteristic feature of transition elements?
(A) They are robust metals possessing notably high melting and boiling points.
(B) Most of them possess the ability to exhibit variable valencies.
(C) Most of them naturally form completely colourless aqueous ions and solid compounds.
(D) Most of them act as highly effective chemical catalysts.

Ans : (C)

The chemical substances occupying the central portion of the classification chart are notoriously famous for producing vibrantly coloured aqueous solutions and solid crystalline structures. The assertion claiming they mostly generate completely colourless ionic species strongly contradicts their verified experimental behavior.

39. The highly reactive non-metals fluorine, chlorine, bromine, and iodine belong to Group What does the traditional term "halogen" literally translate to?
(A) Water-producing
(B) Salt-forming
(C) Acid-generating
(D) Gas-emitting

Ans : (B)

The specific nomenclature for this highly reactive family originates from ancient Greek terminology. When these non-metallic substances react directly with various metallic elements, they readily produce ionic crystalline compounds. Therefore, their designated name literally translates to the phrase salt producer.

40. Alkaline earth metals often produce brilliantly coloured displays during thermal excitation. Which of the following alkaline earth metals does NOT impart any characteristic visible colour to an open flame?
(A) Calcium
(B) Strontium
(C) Barium
(D) Magnesium

Ans : (D)

While most members belonging to the second vertical column generate brilliant visual displays when exposed to intense heat, certain lighter elements behave differently. Both beryllium and magnesium possess exceptionally tightly bound electrons that firmly resist thermal excitation during flame testing.

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and chemical properties of elements are periodic functions of their
(A) Atomic masses
(B) Number of neutrons
(C) Atomic volumes
(D) Atomic numbers

Ans : (D)

When chemical substances are arranged sequentially according to the number of protons present inside their nuclei, elements exhibiting comparable characteristics appear at regular intervals. This regular repetition strongly confirms that nuclear charge governs the overall chemical behaviour of the substance.

22. The atomic radius of elements shows a distinct trend across a period. The table shows the atomic radii for some elements of Period 2. Based on the established trend, what is the most likely atomic radius for Nitrogen (N)?
Specification: A table of Period 2 elements and their atomic radii in picometres (pm), with one value missing.

Element	**Li**	**Be**	**B**	**C**	**N**	**O**	**F**
Atomic Radius (pm)	152	112	88	77	X	66	64

(A) 160 pm
(B) 112 pm
(C) 75 pm
(D) 65 pm

Ans : (C)

Atomic radius decreases across a period from left to right due to an increase in nuclear charge pulling the electron shells closer. The data shows a decreasing trend: $152 > 112 > 88 > 77$. The value for Nitrogen (X) must be between Carbon (77 pm) and Oxygen (66 pm). 75 pm is the only logical fit in this trend.

23. Match the periods in List-I with their corresponding characteristics in List-II.
List-I (Period)
P. Period 1
Q. Period 2
R. Period 4
S. Period 6
List-II (Characteristics)
I. Contains exactly 8 elements
II. Known as the longest period
III. Contains exactly 2 elements
IV. Contains exactly 18 elements
(A) P-III, Q-I, R-IV, S-II
(B) P-III, Q-I, R-II, S-IV
(C) P-I, Q-III, R-IV, S-II
(D) P-II, Q-IV, R-I, S-III

Ans : (A)

The first horizontal row accommodates only two chemical substances. The second row expands to hold eight elements. The fourth row contains eighteen members, introducing transition metals. The sixth row includes thirty-two elements, encompassing the lanthanide series, making it the longest.

24. Elements belonging to Group 1, 2, 13, 14, 15, 16, and 17 display a consistent gradient from metallic to non-metallic nature. These elements are collectively known as
(A) Transition elements
(B) Inner transition elements
(C) Representative elements
(D) Noble gases

Ans : (C)

These specific columns consist of chemical substances possessing incomplete outermost electron shells. They exhibit typical chemical behaviour and display a consistent gradient from metallic to non-metallic nature across the table, earning them the title of normal or main group elements.

25. Alkali metals are extremely reactive chemical substances. What is the correct order of increasing reactivity among the following alkali metals?
(A) Li < Na < K < Rb
(B) Rb < K < Na < Li
(C) Li < K < Na < Rb
(D) Na < Li < K < Rb

Ans : (A)

Elements in the first vertical column become progressively larger as additional electron shells are introduced. The outermost electron moves further away from the attractive pull of the positive nucleus, making it significantly easier to lose. Consequently, chemical reactivity steadily increases.

26. Which of the following statements accurately describes the primary characteristic of transition elements?
(A) They have their outermost orbit completely saturated with electrons.
(B) They have their two outermost electron shells incomplete.

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(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (B)

Both statements are factually accurate. However, the reason does not explain the assertion. According to the foundational principle based strictly on atomic mass, isotopes should have been given separate slots. Their omission highlights a fundamental flaw in the classification framework.

17. A period in the modern periodic table consists of elements with the same number of electron shells. Based on the electronic configurations provided in the table, which set of elements belongs to the same period?

Set	Element	Atomic Number	Electronic Configuration
1	P (Z=3)	3	2, 1
	Q (Z=4)	4	2, 2
	R (Z=12)	12	2, 8, 2
2	S (Z=9)	9	2, 7
	T (Z=17)	17	2, 8, 7
	U (Z=18)	18	2, 8, 8
3	V (Z=11)	11	2, 8, 1
	W (Z=14)	14	2, 8, 4
	X (Z=16)	16	2, 8, 6
4	Y (Z=2)	2	2
	Z (Z=10)	10	2, 8
	A (Z=11)	11	2, 8, 1

(A) Set 1
(B) Set 2
(C) Set 3
(D) Set 4

Ans : (C)

The period number corresponds to the number of occupied electron shells. In Set 3, elements V, W, and X all have three electron shells (K, L, M) in their configuration. This indicates they all belong to Period 3. In other sets, the elements have a different number of shells and thus belong to different periods.

18. Mendeleev occasionally violated his own rule of increasing atomic mass to maintain group similarities. Which of the following pairs represents such an anomalous pair?

(A) Lithium and Beryllium
(B) Cobalt and Nickel
(C) Carbon and Nitrogen
(D) Sodium and Potassium

Ans : (B)

To maintain groups possessing similar chemical characteristics, strict adherence to increasing atomic weights was occasionally violated. Cobalt, possessing an atomic mass of fifty-eight point nine, was deliberately placed before nickel, which has a slightly lower atomic mass of fifty-eight point six.

19. In 1913, Henry Moseley discovered a fundamental property of elements by measuring X-ray wavelengths. This crucial discovery established that

(A) Atomic mass dictates the ultimate chemical reactivity of all substances.
(B) The number of neutrons primarily determines molecular bonding behaviour.
(C) Atomic number is a significantly better fundamental property than atomic mass.
(D) Isotopes naturally possess identical atomic masses but radically different atomic numbers.

Ans : (C)

Experimental observations of X-ray emissions conclusively demonstrated that the magnitude of positive charge inside the nucleus dictated elemental characteristics. This established the atomic number as a far more reliable foundational basis for systematic classification compared to the previously used atomic mass.

20. What is the total number of horizontal rows and vertical columns that constitute the structure of the Modern Periodic Table?

(A) 7 periods and 8 groups
(B) 7 periods and 18 groups
(C) 18 periods and 7 groups
(D) 8 periods and 18 groups

Ans : (B)

The comprehensive structure of the modern arrangement consists of exactly seven horizontal rows, which indicate the number of electron shells. Additionally, it contains eighteen distinct vertical columns containing elements that share identical valence electron configurations and exhibit similar chemical properties.

21. The structural foundation of modern chemistry relies entirely on the Modern Periodic Law. This fundamental law states that the physical

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It predictably climbs from one to four as the available outermost electrons multiply. Following the halfway mark, elements begin requiring fewer shared electrons to achieve stability, reducing valency.

31. A student recorded the atomic radii of the first three alkali metals (Group 1). Analyse the data in the table and select the correct conclusion about the trend in atomic size down a group.

Element	**Period**	**Number of Shells**	**Atomic Radius (pm)**
Lithium (Li)	2	2	152
Sodium (Na)	3	3	186
Potassium (K)	4	4	227

(A) Atomic size decreases down a group as nuclear charge increases.
(B) Atomic size remains constant as the number of valence electrons is the same.
(C) Atomic size increases down a group due to the addition of a new electron shell.
(D) Atomic size shows no predictable trend down a group.

Ans : (C)

The table clearly shows that as we move down Group 1 from Lithium to Potassium, the atomic radius increases (152 pm $<$ 186 pm $<$ 227 pm). This is because each successive element has an additional electron shell, which increases the overall size of the atom, overriding the effect of increased nuclear charge.

32. Consider the oxides of the third period elements Na_2O, MgO, Al_2O_3, SiO_2, P_2O_5, SO_3, Cl_2O_7. What is the general trend in the character of these oxides moving horizontally?
(A) They become progressively more highly basic.
(B) They consistently remain perfectly amphoteric throughout.
(C) They logically change from basic to amphoteric, and finally to acidic.
(D) They steadily change from acidic to neutral, and finally to basic.

Ans : (C)

Horizontal progression brings a gradual transition from distinctly metallic substances to entirely non-metallic ones. Consequently, the compounds they form with oxygen initially demonstrate strongly alkaline behaviour, transition through an intermediate dual-nature phase, and ultimately exhibit highly acidic chemical characteristics.

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33. An unknown chemical element possesses an atomic number of To which specific group and period does this substance belong in the Modern Periodic Table?
(A) Group 5, Period 2
(B) Group 15, Period 3
(C) Group 5, Period 3
(D) Group 15, Period 2

Ans : (B)

The atomic number fifteen corresponds to an electronic configuration of two, eight, five. The presence of three occupied energy shells indicates it belongs to the third horizontal row. Adding ten to its five outermost electrons assigns it to group fifteen.

34. Elements of the second period sometimes show a strong resemblance in properties with elements of the next group of the third period. Which of the following pairs correctly represents these bridge elements?
(A) Lithium and Calcium
(B) Beryllium and Aluminium
(C) Boron and Phosphorus
(D) Carbon and Sulphur

Ans : (B)

Substances occupying specific adjacent diagonal positions frequently display remarkably analogous chemical characteristics. For instance, the second-row element beryllium shares distinct functional similarities with the third-row element aluminium. This unique phenomenon effectively links the properties across two sequentially adjacent groups.

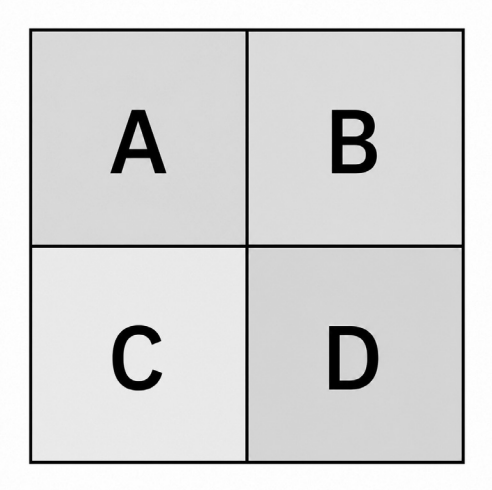
35. Consider the following statements regarding the physical and chemical properties of Alkali Metals (Group 1)
I. They invariably possess exactly one electron in their outermost orbit.
II. They easily form stable unipositive ions and behave as strong reducing agents.
III. They are found abundantly in a completely free, uncombined state in nature.
IV. They vigorously react with water molecules to produce hydrogen gas.
Which of the statements are correct?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

(C) They exclusively include all highly reactive elements of the s and p blocks.
(D) They consist entirely of naturally occurring and synthetic radioactive elements.

Ans : (B)

These substances occupy the central block of the classification table, spanning from group three to twelve. Their defining characteristic is the presence of two partially filled outermost electron shells. This unique atomic structure allows them to exhibit variable chemical valencies.

27. A section of the periodic table grid is shown with four elements A, B, C, and D. Which element is expected to have the most pronounced metallic character?



(A) A
(B) B
(C) C
(D) D

Ans : (C)

Metallic character increases down a group and decreases across a period. Element C is located below element A (same group) and to the left of element D (same period). Therefore, C is in a lower period and an earlier group than the others, which is the region of highest metallic character among the choices.

28. Consider the following statements regarding the general trends when moving downwards in a particular group

I. The number of valence electrons progressively increases.
II. The total number of electron shells progressively increases.
III. The physical atomic size of successive elements increases.
IV. The chemical valency of the representative elements remains the same.

Which of the above statements are correct?
(A) I, II, and III
(B) II, III, and IV
(C) I, III, and IV
(D) I, II, and IV

Ans : (B)

Moving vertically downwards introduces an additional electron shell at each subsequent step, causing the overall atomic radius to expand. Since elements within the identical vertical column possess the exact same count of outermost electrons, their combining capacity remains entirely constant.

29. Read the assertion and reason carefully and select the correct option.
Assertion (A) : The size of an atom gradually decreases when moving from left to right across a given period.
Reason (R) : The total number of electron shells decreases when moving from left to right across a period.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Atomic radius shrinks horizontally because increasing proton counts strengthen the nuclear pull on outer electrons. However, the accompanying is completely incorrect. The total count of occupied electron orbits always remains constant for every single element positioned within one period.

30. How does the valency of typical representative elements with respect to hydrogen vary as one moves from left to right across a period?
(A) It continuously increases from 1 to 7.
(B) It remains entirely unchanged throughout the entire period.
(C) It arithmetically increases from 1 to 4 and then decreases to 1.
(D) It gradually decreases from 4 to 1 and then rapidly increases to 4.

Ans : (C)

Combining capacity relative to hydrogen strictly depends on the valence shell configuration.

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41. The extremely heavy elements occupying the lower separate portion of the sixth and seventh periods are collectively known as inner transition elements. They exclusively consist of
(A) Alkali and alkaline earth metals
(B) Halogens and unreactive noble gases
(C) Lanthanides and radioactive actinides
(D) Metalloids and highly electronegative non-metals

Ans : (C)

These exceptionally heavy metallic substances are conventionally placed completely outside the primary tabular structure to maintain proper visual formatting. They strictly comprise two horizontal sequences consisting of fourteen distinct elements each, originating directly after lanthanum and actinium in the chart.

42. A section of Newlands' Octaves arrangement is shown. According to his law, every eighth element should have properties similar to the first. Based on the table and modern chemical knowledge, which element is incorrectly placed in its column?

sa (do)	**re (re)**	**ga (mi)**	**ma (fa)**	**pa (so)**	**da (la)**	**ni (ti)**
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe

(A) Na under Li
(B) Mg under Be
(C) Fe under O
(D) Cl under F

Ans : (C)

In Newlands' arrangement, Fe (a metal) is placed under O (a non-metal), which is a significant mismatch in properties. Iron's properties are very different from those of oxygen and sulphur. The other pairs (Li/Na, Be/Mg, F/Cl) are correctly grouped as they share similar chemical properties, fitting the Law of Octaves for lighter elements.

43. Read the assertion and reason carefully and select the correct option.
Assertion (A) : Elements belonging to the zero group hardly ever participate in chemical reactions with other elements.
Reason (R) : Every single member of the zero group possesses exactly two electrons in its outermost orbit.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

These extremely unreactive gaseous substances possess fully saturated external electron shells, effectively eliminating chemical interactions. However, the stated contains a fundamental inaccuracy. While helium indeed possesses two outer electrons, every other member within this family possesses exactly eight.

44. Despite numerous modern advancements, the exact position of hydrogen remains somewhat undecided in the classification system. What is the primary reason for this ambiguity?
(A) Because it exists completely as a free-flowing liquid at standard room temperature.
(B) Because its total atomic mass is far too low to be properly classified.
(C) Because it simultaneously shows structural similarity in properties with both alkali metals and halogens.
(D) Because it is artificially synthesized in laboratories and possesses highly unstable radioactive properties.

Ans : (C)

This unique substance displays a distinctly dual chemical personality. Just like group one elements, it forms positive ions and exhibits a single valence electron. Simultaneously, it perfectly mimics group seventeen elements by forming diatomic gaseous molecules and acquiring negative charges.

45. Noble gases possess incredibly unique characteristics compared to standard representative elements. Which of the following statements about noble gases is factually incorrect?
(A) They exist exclusively as highly stable mono atomic gases.
(B) They are highly inflammable and strongly support vigorous combustion.
(C) They can technically be liquefied, but only with exceptionally great difficulty.
(D) They uniquely emit brightly coloured light when an electrical discharge passes through them.

Ans : (B)

Due to their inherently stable electronic configurations, these inert elements entirely refuse to participate in rapid oxidation reactions.

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Consequently, they absolutely never ignite upon exposure to open flames, nor do they ever assist other surrounding combustible materials in burning.

46. The metallic character of elements changes across a period. The table provides information for elements A, B, and C from the same period. Based on this data, arrange the elements in order of decreasing metallic character.
Specification: A table showing hypothetical elements, their group number, oxide nature, and bonding in chloride.

Element	Group	Nature of Oxide	Bonding in Chloride
A	1	Strongly Basic	Ionic
B	14	Acidic	Covalent
C	17	Strongly Acidic	Covalent

(A) A > B > C
(B) C > B > A
(C) A > C > B
(D) B > A > C

Ans : (A)

Metallic character is associated with forming basic oxides and ionic bonds. Element A (Group 1) forms a strongly basic oxide and an ionic chloride, indicating it is the most metallic. Element B (Group 14) and C (Group 17) form acidic oxides and covalent chlorides, indicating non-metallic character, which increases towards the right. Therefore, the order of decreasing metallic character is A > B > C.

47. Specific elemental properties dictate real-world industrial applications. Which zero-group element is commonly utilised in airships and weather balloons due to being both exceptionally light and highly unreactive?
(A) Argon
(B) Helium
(C) Neon
(D) Krypton

Ans : (B)

For atmospheric elevation purposes, a highly specific gaseous substance is required. Because this element possesses incredibly low mass while completely lacking any explosive or flammable properties, it serves as the perfectly safe and ideal lifting agent for large aerial vehicles.

48. Match the numerical group classifications in List-I with their corresponding common elemental family names in List-II.
List-I (Group)
P. Group 1
Q. Group 2
R. Group 16
S. Group 17
List-II (Common Name)
I. Oxygen family
II. Alkaline earth metals
III. Halogens
IV. Alkali metals
(A) P-IV, Q-II, R-I, S-III
(B) P-IV, Q-II, R-III, S-I
(C) P-II, Q-IV, R-I, S-III
(D) P-I, Q-III, R-IV, S-II

Ans : (A)

The first vertical column contains extremely reactive water-soluble base formers. The second column features slightly less reactive base-forming metals. The sixteenth column is officially initiated by oxygen. The seventeenth column exclusively houses highly reactive salt-producing non-metallic chemical substances.

49. To successfully determine the specific period to which a normal representative element belongs, one must properly analyse its electronic configuration. Which specific feature of the configuration directly determines the period number?
(A) The exact total number of valence electrons present
(B) The total consecutive number of occupied electron shells
(C) The total combined number of nuclear protons
(D) The absolute number of heavily shielded core electrons

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Ans : (B)

The horizontal placement of any normal element directly corresponds to its atomic physical structure. The exact quantity of distinct energy levels containing electrons determines its row. Thus, an atom utilising exactly three orbits automatically occupies the third horizontal row.

50. Due to their incredibly aggressive chemical nature, elements belonging to Group 1 demand highly specialised storage methods. Why are they typically kept submerged in inert solvents like kerosene?

(A) To artificially enhance and permanently increase their natural metallic lustre
(B) To entirely prevent their violent reaction with oxygen and moisture in the air
(C) To significantly decrease their otherwise extremely high melting and boiling points
(D) To effectively stop them from continuously undergoing dangerous radioactive nuclear decay

Ans : (B)

These highly active metallic substances tarnish instantly upon direct atmospheric exposure. If permitted to interact freely with ambient water vapour or oxygen, they rapidly initiate violently explosive chemical reactions. Submerging them safely isolates their reactive surfaces from the surrounding environment.

51. The reactivity of halogens (Group 17) decreases down the group. A student records observations from the reactions of Fluorine, Chlorine, and Bromine. Which observation correctly reflects this trend?

Halogen	**Period**	**Observation on Reactivity**
Fluorine (F)	2	Reacts explosively with hydrogen, even in the dark.
Chlorine (Cl)	3	P
Bromine (Br)	4	Reacts slowly with hydrogen only upon heating.

(A) P = Reacts with hydrogen only with a platinum catalyst.
(B) P = Does not react with hydrogen under any condition.
(C) P = Reacts with hydrogen only in the presence of sunlight.
(D) P = Reacts more explosively with hydrogen than fluorine.

Ans : (C)

The table shows that reactivity decreases from Fluorine (Period 2) to Bromine (Period 4). Fluorine reacts explosively, while Bromine requires heat. Chlorine (Period 3) should have an intermediate reactivity. Reacting with hydrogen in the presence of sunlight is a less vigorous condition than exploding in the dark, but more vigorous than requiring heat, fitting the established trend perfectly.

52. Halogens are renowned for their aggressive non-metallic behaviour. What is the correct observed trend for the chemical reactivity of halogens as one progresses downwards from fluorine to iodine?
(A) Reactivity constantly and exponentially increases.
(B) Reactivity logically first increases, then sharply decreases.
(C) Reactivity constantly and progressively decreases.
(D) Reactivity remains completely unchanged regardless of position.

Ans : (C)

(A) the atomic radius significantly expands downward, the central nucleus progressively loses its ability to attract incoming shared electrons. Because their entire chemical functionality relies entirely upon readily acquiring an extra electron, these non-metals steadily become less chemically aggressive.

53. Studying the precise location of an element within the tabular classification provides immense structural insight. The position of an element directly helps to reveal all of the following EXCEPT its
(A) Valence electronic configuration
(B) Exact historical date of discovery
(C) Chemical valency
(D) General metallic or non-metallic nature

Ans : (B)

While the systematic arrangement beautifully displays essential atomic structures, outermost electron counts, and fundamental chemical behaviours, it strictly serves as a scientific functional guide. It entirely lacks any historical timelines regarding when specific substances were successfully identified by early scientists.

54. Read the assertion and reason carefully and select the correct option.
Assertion (A) : Metallic character consistently increases upon moving downwards along any given group in the periodic table.
Reason (R) : The effective nuclear attraction decreases due to the subsequent addition of new electron shells, making it easier to lose valence electrons.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A

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have different masses but identical chemical properties, their position could not be properly explained in Mendeleev's table. This difficulty was removed in the modern periodic table based on atomic number.

77. Why are alkali metals called good reducing agents?
(A) They gain electrons easily
(B) They have complete octets
(C) They lose electrons easily
(D) They are inert gases

Ans : (C)

Explanation: Alkali metals possess one valence electron and have low ionization energy. They readily lose this electron to form positive ions. Since they donate electrons to other substances, they act as strong reducing agents. Their reducing power generally increases down the group as atomic size increases.

ONE MARK QUESTIONS

78. In a group where do you expect to find the most metallic element?

Ans :
(A) the bottom.

79. In a group where do you expect to find the element having maximum size?

Ans :
(A) the bottom.

80. In which group Lanthanoids and Actinoids are present?

Ans :
Group 3.

81. How many periods and groups are there in the long form of periodic table.

Ans :
7 periods and 18 groups.

82. What happens to the basic character of oxides when we move down the group ?

Ans :
(A) we move down the group, the basic character of oxides increases.

83. What happens to the acidic character of elements in a period?

Ans :
(A) we move across the period, the acidic character of oxides increases.

84. What is/are the valency/valencies of metal?

Ans :
Valency of metals are 1, 2 or 3.

85. Where are lanthanoids placed in the periodic table?

Ans :
They are placed outside of the main body of the periodic table.

86. By what other name the zero group elements are known?

Ans :
They are known as inert gases.

87. How many actinoids are there in the modern periodic table?

Ans :
Fourteen, starting actinium (atomic number 90 to 103).

88. What happens to the metallic character when we move from left to right in a period?

Ans :
(A) we move from left to right in a period, metallic character increases.

89. Name two alkali metals.

Ans :
Na, K

90. Name two alkaline earth metals.

Ans :
Ca, Mg

91. Name the shortest period.

Ans :
First

92. Name the incomplete period in periodic table.

Ans :
Seventh period.

93. If an element has electronic configuration 2, 8, 2. Predict its position in periodic table.

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59. Let us carefully consider the elements constituting Group 15 N, P, As, Sb, Bi. The element Bismuth (Bi) acts as a typical metal. The chemical oxide formed by Bismuth (Bi_2O_3) is consequently expected to be
(A) Highly acidic
(B) Completely neutral
(C) Distinctly amphoteric
(D) Strongly basic

Ans : (D)

Moving downwards along a vertical column causes a steady increase in metallic properties. Because the element located at the very bottom functions as a true metal, the chemical compound it produces upon reacting with oxygen displays a distinctly alkaline nature.

60. To unify global scientific standards, IUPAC strongly recommended substituting older group notations featuring letters and Roman numerals. The older historical notation of Group VIIA directly corresponds to which specific numerical group under the new system?
(A) 7
(B) 15
(C) 17
(D) 18

Ans : (C)

The modern international scientific standard entirely eliminated complex Roman numerals and alphabet letters. Instead, it adopted a straightforward sequential numbering system spanning from one to eighteen. Consequently, the column containing the highly reactive salt producers was officially redesignated as seventeen.

61. Combining capacity heavily dictates how elements interact to build compounds. What is the fundamental valency of the unreactive gaseous elements belonging exclusively to Group 18 of the periodic classification?
(A) 8
(B) 0
(C) 1
(D) 2

Ans : (B)

The outermost electron paths of these particular gaseous elements are completely occupied. Because they totally lack any underlying requirement to gain, lose, or share external electrons to achieve thermodynamic stability, their practical combining capacity remains absolutely zero under normal circumstances.

62. Based strictly on the arrangement of electronic configurations, which specific category inside the Modern Periodic Table primarily contains chemical elements that function as exceptionally poor conductors of heat and electricity?
(A) Typical Alkali metals
(B) Heavy Transition metals
(C) Non-metals placed in groups 16 and 17
(D) Standard Alkaline earth metals

Ans : (C)

The extreme right section of the classification table accommodates non-metallic chemical substances. Due to their tightly bound valence electrons and completely absent free-flowing charge carriers, these specific elements demonstrate extremely poor efficiency when transmitting thermal energy or electrical currents.

63. The table shows the formulae of oxides for elements in Period 3. Based on the observed trend, what is the correct formula for the oxide of the element marked 'X'?

Element	Na	Mg	Al	Si	X (Phosphorus)
Formula of Oxide	Na_2O	MgO	Al_2O_3	SiO_2	?

(A) P_2O_3
(B) PO_2
(C) P_2O_5
(D) PO

Ans : (C)

Across a period, the valency of an element with respect to oxygen generally increases. For Period 3, the valencies are Na(1), Mg(2), Al(3), Si(4). Following this trend, Phosphorus (in Group 15) exhibits a valency of 5 in its highest oxide, leading to the formula P_2O_5.

64. Consider the following statements regarding the distinct structural merits of the Modern Periodic Table over earlier classification attempts
I. It is logically based directly upon the atomic mass of elements.
II. All identified isotopes of a specific element perfectly occupy the exact same place.
III. The previously problematic position of anomalous pairs like argon and potassium is completely corrected.
IV. Elements possessing highly similar outer electronic configurations are systematically grouped together.

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Which of the statements are correct?
(A) I, II, and III
(B) II, III, and IV
(C) I, III, and IV
(D) I, II, and IV

Ans : (B)

The structural foundation completely shifted from mass to nuclear proton count, logically solving previous anomalies. Because identical elements share matching atomic numbers, their variations naturally share single slots. Furthermore, substances exhibiting matching outermost shell designs logically gather within vertical columns.

65. The valency of elements with respect to oxygen increases across a period. The table below shows the oxides of some Period 3 elements. What is the correct valency of Phosphorus (P) with respect to oxygen, based on the pattern?
Modification: Columns for element, oxide formula, and valency. A value is hidden.

Element	**Na**	**Mg**	**Al**	**Si**	**P**	**S**
Oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3
Valency	1	2	3	4	Y	

(A) 2
(B) 3
(C) 4
(D) 5

Ans : (D)

The table demonstrates a clear trend where the valency of the element with respect to oxygen increases by one for each step across the period: Na(1), Mg(2), Al(3), Si(4). Following this pattern, Phosphorus (P) should have a valency of 5, which corresponds to its oxide formula P_2O_5.

66. As one systematically evaluates the extensive classification chart, distinct patterns consistently emerge. What is the fundamental primary cause of periodicity, or the highly predictable recurrence of similar chemical properties at regular intervals?
(A) The repetitive recurrence of identical elemental atomic masses
(B) The cyclical recurrence of perfectly matching atomic sizes
(C) The periodic recurrence of the exact same outermost shell electronic configuration
(D) The mathematical recurrence of the identical total number of electrons

Ans : (C)

(A) the atomic numbers continuously climb sequentially, distinct valence electron arrangements repeat mathematically. Because identical outermost orbital layouts directly dictate identical interactive chemical behaviours, elements located within identical vertical columns consistently demonstrate wonderfully predictable and remarkably similar elemental traits.

67. Read the assertion and reason carefully and select the correct option.
Assertion (A) : When elements of Group 1 directly combine with elements of Group 17, they invariably form highly stable electrovalent or ionic chemical compounds.
Reason (R) : Group 1 metallic elements easily lose valence electrons to form positive ions, while Group 17 non-metallic elements eagerly gain electrons to form negative ions.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Highly reactive metallic substances enthusiastically surrender their single external electrons, establishing stable positive charges. Simultaneously, reactive non-metals eagerly accept these discarded particles, achieving negative states. Strong electrostatic forces firmly bind these oppositely charged ions together into perfectly structured crystalline lattices.

68. The modern periodic table is arranged according to:
(A) Atomic mass
(B) Density
(C) Atomic number
(D) Valency

Ans : (C)

Explanation: The modern periodic table is based on Moseley's periodic law, which states that the physical and chemical properties of elements are periodic functions of their atomic numbers. Atomic number is a more fundamental property than atomic mass because it represents the number of protons in the nucleus and determines the electronic configuration of an element.

69. How many groups are present in the modern periodic table?
(A) 7

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(B) 8
(C) 18
(D) 32

Ans : (C)

Explanation: The modern periodic table contains 18 vertical columns known as groups. Elements in the same group have the same number of valence electrons and therefore show similar chemical properties. For example, all Group 1 elements have one valence electron and are called alkali metals.

70. The horizontal rows in the periodic table are called:
(A) Series
(B) Groups
(C) Periods
(D) Families

Ans : (C)

Explanation: Horizontal rows in the periodic table are called periods. There are seven periods in the modern periodic table. Elements in the same period have the same number of electron shells, but their valence electrons increase from left to right, causing gradual changes in properties.

71. Which group is known as the Halogens?
(A) Group 1
(B) Group 2
(C) Group 17
(D) Group 18

Ans : (C)

Explanation: Group 17 elements are called halogens, meaning "salt producers." They include fluorine, chlorine, bromine, iodine and astatine. These elements have seven valence electrons and readily gain one electron to attain stable electronic configuration. They are highly electronegative and strong oxidizing agents.

72. Which group contains the Noble Gases?
(A) Group 1
(B) Group 2
(C) Group 17
(D) Group 18

Ans : (D)

Explanation: Group 18 contains the noble gases such as helium, neon, argon, krypton, xenon and radon. These gases possess complete outer electron shells and therefore have zero valency. Because of their stable electronic configuration, they are chemically inert under ordinary conditions.

73. Why do elements in the same group show similar chemical properties?
(A) Same atomic mass
(B) Same number of neutrons
(C) Same number of valence electrons
(D) Same density

Ans : (C)

Explanation: Chemical properties mainly depend on valence electrons. Elements belonging to the same group have the same number of valence electrons and therefore exhibit similar chemical behaviour. For example, sodium and potassium both have one valence electron and react similarly with water.

74. Which period is known as the shortest period?
(A) First period
(B) Second period
(C) Third period
(D) Fourth period

Ans : (A)

Explanation: The first period contains only two elements—hydrogen and helium. Because it has the smallest number of elements, it is called the shortest period. In contrast, later periods contain more elements due to the availability of additional electron shells and subshells.

75. As we move down a group, atomic size generally:
(A) Decreases
(B) Remains constant
(C) Increases
(D) Becomes zero

Ans : (C)

Explanation: Moving down a group adds a new electron shell to each successive element. The increased number of shells places the outermost electrons farther from the nucleus. As a result, the atomic radius increases from top to bottom within a group.

76. Which of the following is a limitation of Mendeleev's Periodic Table?
(A) It contained 18 groups
(B) It was based on atomic number
(C) Position of isotopes was not explained
(D) It included noble gases initially

Ans : (C)

Explanation: Mendeleev arranged elements according to atomic masses. Since isotopes

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(ii) Inner transition elements placed in sixth period are called _____.
(iii) Metals form _____ oxides.
(iv) Metallic character _____ on moving across a period.
(v) Metallic character _____ on going down a group.

Ans :

(i) Lanthanoids, actinoids
(ii) Lanthanoids
(iii) basic
(iv) decreases
(v) increases

DIRECTION : Name the following :

102. Name the following:
(i) Zero group elements.
(ii) Longest period of the periodic table.
(iii) Incomplete period of the periodic table.
(iv) Group 1 elements.
(v) Horizontal rows of the periodic table.

Ans :

(i) Inert gases
(ii) Sixths Period
(iii) Seventh Period
(iv) Alkali Metals
(v) Periods.

103. Name the following
(i) Two elements whose atomic weight was corrected.
(ii) Two elements for which gaps were left.
(iii) Triad formed by alkaline earth metal.

Ans :

(i) Gold and platinum
(ii) Germanium and scandium
(iii) Calcium, strontium and barium

104. State whether the following statement is true or false.
Alkaline earth metals are present in group 2 of the periodic table.

Ans :

True

105. Write the valency of
(i) Alkali metal (ii) Alkaline earth metals
(iii) Halogens (iv) Zero group elements

Ans :

(i) +1 (ii) +2
(iii) – 1 (iv) 0

106. Match the following:

	Column I		**Column II**
(i)	Argon	(a)	Halogen
(ii)	Bromine	(b)	Alkali metal
(iii)	Potassium	(c)	Alkaline earth metal
(iv)	Oxygen	(d)	Inert gas
(v)	Calcium	(e)	Chalcogen

Ans :

(i) d (ii) a (iii) b
(iv) e (v) c

107. Match the following:

	Column I		**Column II**
(i)	First period	(a)	8 elements
(ii)	Second period	(b)	32 elements
(iii)	Fourth period	(c)	2 elements
(iv)	Sixth period	(d)	Incomplete period
(v)	Seventh period	(e)	18 elements

Ans :

(i) c (ii) a (iii) e
(iv) b (v) d

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TWO MARKS QUESTIONS

108. A student says, "Chlorine and Argon are placed next to each other in the same period, so their chemical properties must be similar." Do you agree? Give two reasons.

Ans :

No, I do not agree.
Chlorine has 7 valence electrons whereas Argon has 8 valence electrons.
Chlorine is highly reactive, while Argon is chemically inert due to its complete octet.

109. An unknown element X forms an oxide X_2O. Predict its group and explain your answer.

Ans :

Oxygen has valency 2; therefore each X atom must have valency 1.
Elements with valency 1 belong to Group 1 (alkali metals).

Ans :

Group – 2, Period – 3.

94. The metals of Group 2 from top to bottom are Be, Mg, Ca, Sr and Ba.
State the common feature in the electronic configuration of all these elements.

Ans :

They all contain two valence electrons.

95. What is the cause of periodicity in properties?

Ans :

The cause of periodicity in properties is due to the repetition of similar outer electronic configuration at cetrain regular intervals.

96. What is meant by periodicity?

Ans :

Periodicity: The gradation of properties of elements as the atomic numbers increase is called periodicity.

97. State the merit of Dobereiner's triads.

Ans :

It was first attempt which gives the relation between the properties of an element to its atomic weight.

98. Give one word answer:
(i) Scientist who left gaps in his periodic table.
(ii) Classification in which elements are grouped in a group of three.
(iii) Classification in which first and eighth elements are similar.
(iv) Law which states that the properties of elements are a periodic functions of their atomic masses.
(v) A table or chart in which elements are arranged in periods and groups.

Ans :

(i) Mendeleev
(ii) Dobereiner's Triads
(iii) Newland's Octaves
(iv) Mendeleev's Periodic Law
(v) Periodic Table.

DIRECTION : Fill in the blanks

99. The following questions are related with the long form of periodic table.
(i) The physical and the chemical properties of the elements are the ..... functions of their atomic numbers..
(ii) In which group halogens are placed in the long form of periodic table?
(iii) In the long form of periodic table, the elements are arranged in the ascending order of _____
(iv) The number of shells is equal to the number of _____
(v) _____ metals are present in group 1 of the periodic table.
(vi) The _____ metals are placed in group 2 of the periodic table.
(vii) The first period has _____ elements. The elements are _____ and _____
(viii) At the end of every period, an _____ gas is present.

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Ans :

(i) periodic
(ii) Group 17
(iii) atomic number
(iv) periods.
(v) Alkali
(vi) alkaline earth
(vii) two, hydrogen and helium.
(viii) inert

100. Fill in the blanks.
(i) Representative elements have _____ penultimate shells.
(ii) Transition elements have _____ penultimate shells.
(iii) Vertical lines are called _____.
(iv) Horizontal lines are called _____.
(v) There are _____ vertical lines in the periodic table.
(vi) Modern periodic law is given by _____.
(vii) Inert gases have _____ valency.
(viii) The elements of group 17 are called _____.
(ix) Inert gases are present in group _____.
(x) The highly non-metallic elements are present on _____ side of the periodic table.

Ans :

(i) complete
(ii) incomplete
(iii) groups
(iv) periods
(v) 18
(vi) Moseley
(vii) zero
(viii) halogens
(ix) 18
(x) right

101. Fill in the blanks:
(i) Elements placed at the bottom of periodic table are called _____ and _____.

(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Moving downwards introduces extra orbits, substantially increasing the physical distance between the positively charged centre and outermost orbital paths. This structural expansion significantly weakens the attractive pull, allowing atoms to discard valence electrons much faster, thereby boosting their metallic nature.

55. The table provides the electronic configurations for three alkali metals. How does the data in the table explain their high reactivity?
Modification: Simplified version of the electronic configuration table.

Element	Symbol	Period	Electronic Configuration
Lithium	Li	2	2, 1
Sodium	Na	3	2, 8, 1
Potassium	K	4	2, 8, 8, 1

(A) They have a completely filled outermost shell, making them stable.
(B) They each have a single valence electron which is easily lost.
(C) They have seven valence electrons and tend to gain one electron.
(D) They are in different periods, which makes them highly reactive.

Ans : (B)

The table shows that Lithium, Sodium, and Potassium each have only one electron in their outermost shell (valence shell). Atoms tend to achieve a stable configuration like noble gases. For these elements, losing this single valence electron is energetically favourable, allowing them to form a stable positive ion. This tendency to easily lose an electron makes them highly reactive.

56. Metals belonging to the second vertical column predominantly establish chemical bonds through complete electron transfer. All the alkaline earth metal salts are essentially ionic compounds EXCEPT the salts of which specific element?
(A) Calcium
(B) Strontium
(C) Barium
(D) Beryllium

Ans : (D)

While the majority of the substances located within the second column readily form completely standard electrovalent chemical bonds, the topmost member exhibits unique structural anomalies. Due to its exceptionally tiny atomic dimensions, it heavily favours creating entirely covalent chemical connections.

57. Consider the following statements regarding the distinct physical and chemical properties of typical halogens
I. They constantly exist naturally as bonded diatomic molecules.
II. They consistently form compounds possessing similar formulae, such as HCl, HBr, and HI.
III. They are universally known as highly pleasant-smelling gases.
IV. They exclusively produce positive ions carrying a single electrical charge.
Which of the statements are correct?
(A) I and II
(B) I, II, and III
(C) II and IV
(D) I, III, and IV

Ans : (A)

Members of the seventeenth column consistently pair up naturally and share identical combining capacities when bonding with hydrogen. However, they possess incredibly toxic, pungent odours rather than pleasant ones. Furthermore, they universally accept outer electrons, actively generating negatively charged particles.

58. Alkali metals uniquely serve as powerful reducing agents because they possess an overwhelming tendency to form unipositive ions. If a neutral atom of an alkali metal is represented as M, which chemical equation correctly depicts this transformation?
(A) $M + e^- \longrightarrow M^-$
(B) $M \longrightarrow M^+ + e^-$
(C) $M + 2e^- \longrightarrow M^{2-}$
(D) $M \longrightarrow M^{2+} + 2e^-$

Ans : (B)

Elements occupying the extremely reactive first vertical column possess one lonely electron in their outermost boundary. To attain ultimate chemical stability, they actively discard this negatively charged particle into their environment, permanently transforming into stable positively charged singular ionic species.

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110. A scientist discovers an element with electronic configuration 2,8,8,1. Without naming the element, predict two of its chemical properties.

Ans :

It will readily lose one electron and form a +1 ion.
It will be highly reactive and show metallic character.

111. Why is it incorrect to arrange modern elements according to atomic mass instead of atomic number?

Ans :

Atomic number determines the electronic configuration of an element.
Similar electronic configurations produce similar properties, which may not occur when arranged by atomic mass.

112. A student places fluorine in Group 1 because it needs only one electron to attain stability. Identify the mistake.

Ans :

Group placement depends on the number of valence electrons, not on the number needed for stability.
Fluorine has 7 valence electrons and therefore belongs to Group 17.

113. Element P is in Group 1 and Element Q is in Group Which one is expected to be a better reducing agent? Explain.

Ans :

Element P.
Group 1 elements lose electrons easily.
A reducing agent donates electrons, therefore Group 1 elements are strong reducing agents.

114. An element lies in Period 4 but has only one valence electron. Explain why it is more reactive than the corresponding element in Period 2.

Ans :

The outermost electron is farther from the nucleus due to more shells.
It is lost more easily, increasing reactivity down the group.

115. A chemist finds that an element neither gains nor loses electrons during reactions. What can you infer about its position in the periodic table?

Ans :

It belongs to Group 18 (noble gases).
Its outermost shell is completely filled, making it stable and inert.

116. Two elements belong to the same group. One is a metal while the other is also a metal. Yet their reactivities are different. Explain.

Ans :

Reactivity changes down a group due to increasing atomic size.
The outermost electrons are held less strongly in the lower element, making it more reactive.

117. An element has seven electrons in its outermost shell. Predict the nature of the compound formed when it reacts with sodium and justify your answer.

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Ans :

The compound formed will be ionic.
Sodium loses one electron while the element gains one electron to complete its octet.

118. If Argon had seven valence electrons instead of eight, would it still be placed in Group 18? Give reasons.

Ans :

No.
Group 18 elements have completely filled outermost shells.
With seven valence electrons, Argon would behave like a halogen and be placed in Group 17.

119. Mendeleev left gaps in his periodic table, whereas Newlands did not. Which approach was more scientific? Give two reasons.

Ans :

Mendeleev's approach was more scientific.
He predicted the existence of undiscovered elements.
Newly discovered elements could later be fitted into the gaps without disturbing the table.

120. Write two demerits of modern periodic table.

Ans :

(i) The position of hydrogen is not certain in the periodic table.
(ii) Lanthanoids and actinoids do not find a proper position in the periodic table.

121. What is the importance of periodic table?

Ans :

(i) It helps systematise the study of elements.

Ans :

(a) The chemist was Dobereiner. 1. Dobereiner's Law of Triads states that when elements are arranged in increasing order of atomic mass in a triad, the atomic mass of the middle element is approximately equal to the arithmetic mean of the atomic masses of the other two elements.

(b) Formula:

Mean atomic mass

$$= \frac{\text{Mass of Calcium} + \text{Mass of Barium}}{2}$$

$$= \frac{40 + 137}{2}$$

$$= 88.5$$

(c) Dobereiner could not succeed to arrange all the then known elements in the form of triads, and the law did not fully apply even within the same family.

166. Ananya is examining a chart of Mendeleev's original periodic table during her chemistry class. She notices that he left some vacant spaces for undiscovered elements. She reads that he predicted the properties of an element he named Eka-aluminium, stating its atomic weight would be approximately 68.0 and it would form an oxide with a specific formula. Years later, a new element was discovered that perfectly matched these historical predictions.

(a) Identify the element discovered later that replaced Eka-aluminium and state its actual atomic weight.

(b) Write the formula of the oxide of Eka-aluminium as predicted by Mendeleev.

(c) State the fundamental property of elements that Mendeleev used as the basis for his classification.

Ans :

(a) 1. The element that replaced Eka-aluminium is Gallium.
2. The actual atomic weight of Gallium is 69.70.

(b) The formula of the oxide of Eka-aluminium predicted by Mendeleev is R_2O_3.

(c) Mendeleev used the atomic weight (mass) of the elements as the fundamental property for his classification.

167. Karthik is conducting a project on the development of the modern periodic table. He learns that in 1913, a scientist measured the magnitude of positive charge in the nucleus by measuring the wavelength of X-rays given off by certain metals. This proved that a different fundamental property should dictate the ordering of elements. By applying this new law, Karthik sees that the confusing placement of argon before potassium in the older tables was finally justified.

(a) Name the scientist who proposed this modern periodic law and define the modern periodic law.

(b) Explain the reason why argon is placed before potassium in the modern periodic table despite having a higher atomic mass.

Ans :

(a) 1. The scientist who proposed the modern periodic law is Henry Moseley.
2. The Modern periodic law states that the physical and chemical properties of elements are a periodic function of their atomic numbers.

(b) 1. Elements in the modern periodic table are organized in increasing order of their atomic number rather than atomic mass.
2. Argon has a lower atomic number (18) compared to potassium (19), so argon must be placed before potassium.

168. Meera is working in the school laboratory. She carefully extracts a small, soft piece of a metal stored under kerosene. She cuts it easily with a knife, noting its silvery-white metallic lustre that quickly tarnishes in the air. Her teacher instructs her to perform a flame test with a salt of this metal, and Meera observes a golden yellow flame. Finally, she drops a tiny piece of the metal into a beaker of water and watches it react violently, producing a gas.

(a) Identify the metal based on the flame test and write a balanced chemical equation with state symbols for its reaction with water.

(b) Give two reasons why this metal is kept immersed in an inert solvent like kerosene.

Ans :

(a) 1. The metal is sodium (Na).
2. $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)\uparrow$

(b) 1. Alkali metals are extremely reactive and do not occur in a free state in nature.
2. They rapidly react with oxygen and water vapour present in the air, so they are kept in inert solvents to prevent these violent reactions.

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134. What are the elements of the following groups collectively called:
(a) 17
(b) 18
(c) 1

Ans :
(i) 17 – halogens
(ii) 18 – Inert gases
(iii) 1 – Alkali metals.

135. Choose the odd one in the following list of elements.
(i) F, Cl, Br, Na
(ii) Li, Na, K, Ca
(iii) C, B, Be, Sn
(iv) Sc, Ti, U, He
(v) Ne, Ar, Kr, Fr

Ans :
(i) Na
(ii) Ca
(iii) Sn
(iv) He
(v) Fr

THREE MARKS QUESTIONS

136. An element X has the electronic configuration 2,8,1 while element Y has the configuration 2,8,7.
(a) Identify the groups of X and Y.
(b) Which element is more likely to form a positive ion?
(c) Give a reason for your answer.

Ans :
(a) X belongs to Group 1 and Y belongs to Group 17.
(b) X is more likely to form a positive ion.
(c) X has one valence electron which it can easily lose to attain a stable octet configuration, whereas Y tends to gain one electron.

137. Mendeleev's periodic table was considered superior to Newlands' Law of Octaves. Give three reasons.

Ans :
Mendeleev left gaps for undiscovered elements.
He predicted the properties of these undiscovered elements accurately.
Newly discovered elements could be accommodated without disturbing the arrangement.

138. A student observes that potassium reacts more vigorously with water than sodium.
Explain this observation using the concept of atomic structure.

Ans :
Potassium is placed below sodium in Group 1.
Potassium has an extra electron shell, making its valence electron farther from the nucleus.
Therefore, potassium loses its valence electron more easily and is more reactive.

139. Compare the properties of alkali metals and halogens on the basis of:
(a) Valence electrons
(b) Nature of ions formed
(c) Chemical behaviour

Ans :

Property	Alkali Metals	Halogens
Valence electrons	1	7
Ions formed	Positive ions (cations)	Negative ions (anions)
Chemical behaviour	Lose electrons easily	Gain electrons easily

140. Why are noble gases chemically inactive? How does their electronic configuration affect their valency?

Ans :
Noble gases have completely filled outermost shells.
They do not tend to gain or lose electrons.
Therefore, they have zero valency and are chemically inactive.

141. An element belongs to Group 17 and Period 3.
(a) Identify the element.
(b) State its valency.
(c) Mention one chemical property of this element.

Ans :
(a) Chlorine
(b) Valency = 1
(c) It readily gains one electron to complete its octet and forms chloride ions.

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142. Explain any three advantages of the Modern Periodic Table over Mendeleev's Periodic Table.

Ans :

Elements are arranged according to atomic number rather than atomic mass.
Isotopes occupy the same position because they have the same atomic number.
The anomalous position of several elements is removed.

143. An oxide of an element has the formula M_2O.
(a) What is the valency of M?
(b) To which group is M likely to belong?
(c) State one property of elements of this group.

Ans :

(a) Valency of M = 1
(b) Group 1
(c) They are highly reactive metals and form strongly alkaline hydroxides.

144. Explain the following trends in the periodic table:
(a) Atomic size increases down a group.
(b) Metallic character decreases across a period.
(c) Reactivity of alkali metals increases down the group.

Ans :

(a) New shells are added down the group, increasing atomic size.
(b) The tendency to lose electrons decreases across a period.
(c) The outermost electron becomes easier to lose as atomic size increases.

145. A scientist discovers an element with the electronic configuration 2,8,8.
(a) Identify the group to which it belongs.
(b) Predict its valency.
(c) State whether it is reactive or inert and give a reason.

Ans :

(a) Group 18
(b) Valency = 0
(c) It is inert because its outermost shell is completely filled, giving it a stable electronic configuration.

146. Hydrogen is often called a unique element. Explain why its position in the periodic table is controversial.

Ans :

Hydrogen has one valence electron like alkali metals and can form H_+ ions.
It also requires one electron to complete its shell like halogens and can form H^+ ions.
Therefore, it shows similarities with both Group 1 and Group 17 elements, making its position controversial.

147. Read the following table carefully :

1																	2
3	4 A											5	6	B7	8	9	C10
11 D	12											13	14	15	16E	17	18
19	20	21 F	22	23	24	25 G	26	27	28	29	30	31	32	33	34	35 H	36 I

Which of the lettered element(s) are
(i) inert gas(es)
(ii) transition element(s)
(iii) alkali metal(s)
(iv) alkaline earth metal(s)
(v) halogen (s)
(vi) form(s) diatomic molecule.

Ans :

(i) C, I (ii) F, G
(iii) D (iv) A
(v) H (vi) B and H.

148. Elements A, B and C are the members of triad. Element 'A' has atomic weight 40 and element 'C' has atomic weight 137.6.
(i) What is the atomic weight of 'B'?
(ii) Identify A, B and C.

Ans :

(i) The atomic weight of 'B' is given by

$$\frac{40 + 137.6}{2} = 88.8$$

(ii) A = Calcium
B = Strontium
C = Barium.

149. Identify the element present in the following groups and periods.
(i) 5^{th} period, group 1
(ii) 4^{th} period, group 11
(iii) 2^{nd} period, group 16
(iv) 3^{rd} period, group 17
(v) 4^{th} period, group 18

Ans :

(i) Rubidium (ii) Copper
(iii) Oxygen (iv) Chlorine
(v) Krypton.

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150. Define the following:
(i) Modern periodic law
(ii) Group
(iii) Periods

Ans :
(i) The physical and chemical properties of elements are the periodic function of their atomic numbers.
(ii) The vertical lines in the periodic table are called groups.
(iii) The horizontal rows in the periodic table are called periods.

151. (a) What are the elements of group 1 called?
(b) Name all the elements of group 1.
(c) What type of chlorides are formed by the elements of group 1?

Ans :
(a) Alkali metals
(b) Hydrogen, lithium, sodium, potassium, rubidium, caesium, francium
(c) Ionic chlorides

152. Give reasons:
(i) Group 1 elements are called alkali metals.
(ii) Group 2 elements are called alkaline earth metals.
(iii) Group zero elements are called inert gases.

Ans :
(i) It is because their hydroxides are soluble in water and form strong bases.
(ii) It is because they occur in the earth in free state.
(iii) It is because they have stable configuration following the octet rule.

FOUR MARKS QUESTIONS

153. A, B and C are three elements having the following electronic configurations:
A = 2,8,1
B = 2,8,7
C = 2,8,8
Answer the following:
(a) Identify A, B and C.
(b) State their groups.
(c) Which element is most reactive?
(d) Which element is chemically inert?

Ans :
(a) A = Sodium, B = Chlorine, C = Argon
(b)
A → Group 1
B → Group 17
C → Group 18
(c) Sodium is the most reactive because it readily loses one electron.
(d) Argon is chemically inert because it has a complete octet.

154. Explain any four limitations of Mendeleev's Periodic Table.

Ans :
1. Hydrogen had no fixed position.
2. Isotopes could not be accommodated.
3. Position of rare earth elements was not satisfactory.
4. Position of transition elements created difficulties.

155. Compare Alkali Metals and Halogens under the following headings:
(a) Valence electrons
(b) Valency
(c) Nature of ions formed
(d) Chemical behaviour

Ans :

Property	Alkali Metals	Halogens
Valence electrons	1	7
Valency	+1	-1
Ions formed	Cations	Anions
Chemical behaviour	Lose electrons	Gain electrons

156. Explain why:
(a) Atomic size increases down a group.
(b) Reactivity of alkali metals increases down the group.
(c) Noble gases are chemically inactive.
(d) Halogens are good oxidising agents.

Ans :
(a) New electron shells are added down the group.
(b) Valence electrons become easier to remove due to larger atomic size.
(c) Noble gases have completely filled outermost shells.

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(ii) It helps in correlating the properties of elements with the fundamental properties of element.

122. How many elements are present in
(i) First period?
(ii) Second period?

Ans :

(i) 2 elements
(ii) 8 elements

123. Inert gases have zero valency. Why?

Ans :

Inert gases have zero valency as they can neither lose electron nor they can gain electron because they have complete octet (except helium which has complete duplet).

124. Give reasons:
(i) Metals act as reducing agents.
(ii) Non-metals act as oxidising agents.

Ans :

(i) Metals can easily lose their outermost 1, 2 or 3 electrons to complete their outermost octet, hence they act as reducing agents.
(ii) Non-metals can easily gain electrons to complete their outermost octet, hence they act as oxidizing agents.

125. How is cations and anions formed?

Ans :

Metals lose electrons to form positively charged particles called cations, whereas non-metals gain electrons to form negatively charged particles called anions.

126. Give reason for the following:
Alkali metals are good reducing agents.

Ans :

Alkali metals have one electron in their valence shell and hence they easily lose or donate electron.

127. (a) What are the elements of group 17 called?
(b) Name all the elements of group 17.

Ans :

(a) Halogens
(b) Fluorine, Chlorine, Bromine, Iodine, Astatine.

128. What are representative elements? In which groups these elements are present?

Ans :

The elements which hare complete penultimate shell are called representative elements. The elements present in gp 1, 2, 13, 14, 15, 16, 17 are representative elements.

129. Choose odd one out from the following lists.
(i) Ra, Fr, Li (ii) Cu, Ag, Au, He
(iii) N, P, S, Sb (iv) He, Ne, Cu, Kr

Ans :

(i) Li as others are radioactive.
(ii) He rest are transition metals.
(iii) S rest are the numbers of 15 gp.
(iv) Cu rest are inert gases.

130. Answer the following question related to the periodic table :

1	2											13	14	15	16	17	18
Groups												Groups					
1																	2
3	4A	3	4	5	6	7	8	9	10	11	12	5	6	7	8B	9	10
11C	12	Groups										13	14	15	16	17	18
19	20	21B	22	23	24	25	26	27	28E	29	30	31	32	33	34	35	36

Identify A, B, C, D and E.

Ans :

A – Be, B – O, C – Na, D – Scandium.

131. How many elements are present in
(i) First period (ii) Second period
(iii) Third period (iv) Fourth period
(v) Fifth period (vi) Sixth period

Ans :

(i) 2 (ii) 8 (iii) 8
(iv) 18, (v) 18, (vi) 32

132. Write two merits of Newland's classification of elements.

Ans :

(i) It relates the properties of the elements to their atomic masses or weights.
(ii) This classification worked quite well for lighter elements.

133. Write two limitations of Newland's classification of elements.

Ans :

(i) Newland's classification fails for the heavier elements.
(ii) It did not provide a specific position for hydrogen.

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we get the atomic weight of strontium, i.e. $\frac{40+137}{2} = 88.5$

This classification was not accepted as many elements could not be grouped in triads.

For very low mass or for very high mass elements, the law was not holding good, e.g. F, Cl and Br. Atomic mass of Cl is not the arithmetic mean of atomic masses of F and Br.

161. State Newland's law of Octaves. What was the reason for the failure of this law?

Ans :

Newland arranged the elements in the increasing order of their atomic weights. He suggested that the properties of the elements recur after a regular interval after every seven elements just like the repetition of musical notes.

Newland arranged the elements known at that time in the following manner:

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca					

Failure of Newland's law of octaves:

(i) It was not valid for elements that had atomic masses higher than calcium.

(ii) When more elements were discovered like He, Ne etc., they could not be accommodated in this table.

162. What are the characteristics of long form of periodic table?

Ans :

The different characteristics of the long form of the periodic table are given below:

(i) The highly metallic elements are placed on the left hand side of the periodic table.

(ii) The highly non-metallic elements are placed on the right hand side of the periodic table.

(iii) The transition elements are accommodated between metals and non-metals.

(iv) The noble gases are placed in group 18.

(v) The elements present in the left and right side of the vertical columns are called normal elements or representative elements. The elements having complete penultimate shells are called normal elements or the representative elements.

(vi) Lanthanoids and Actinoids are placed outside the main body of the periodic table.

163. Name the elements occupying the following positions in the periodic table:

S. No.	Group	Period
(i)	17	3
(ii)	16	2
(iii)	2	4
(iv)	1	6
(v)	14	3

Ans :

(i) Chlorine (ii) Oxygen

(iii) Barium (iv) Caesium

(v) Germanium

164. Name all the elements sequentially present in

(i) Group 1 (ii) Group 2

(iii) Period 3 (iv) Period 4

(v) Group 17

Ans :

(i) Hydrogen, Lithium, Sodium, Potassium, Rubidium, Caesium.

(ii) Beryllium, Magnesium, Calcium, Strontium, Barium, Radium.

(iii) Na, Mg, Al, Si, P, S, Cl, Ar.

(iv) K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu. Zn, Ga, Ge, As, Se, Br, Kr.

(v) F, Cl, Br, I, At.

CASE BASED QUEATIONS

165. Rahul is reading a historical chemistry journal in the school library. He reads about early nineteenth-century chemists trying to classify elements to make their study easier. He notes that one German chemist proposed a grouping where three elements had similar properties, and the atomic weight of the middle element was the arithmetic mean of the other two. He finds an example involving calcium, strontium, and barium, but notices the rule did not apply to all known elements.

(a) Name the chemist and state the law of classification he proposed.

(b) Calculate the approximate atomic mass of strontium if the atomic mass of calcium is 40 and that of barium is 137.

(c) State one major drawback of this classification method.

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(d) Halogens readily gain electrons and oxidise other substances.

157. An element X belongs to Group 2 and Period 3.
(a) Identify X.
(b) State its valency.
(c) Will it form a cation or an anion?
(d) Write one characteristic property of this group.

Ans :
(a) Magnesium
(b) Valency = 2
(c) It forms a cation (Mg^{2+}).
(d) Alkaline earth metals are good conductors of heat and electricity.

158. State four advantages of the Modern Periodic Table over Mendeleev's Periodic Table.

Ans ::
1. Elements are arranged according to atomic number.
2. Isotopes occupy the same position.
3. Anomalous pairs are correctly placed.
4. Electronic configuration can be easily understood from an element's position.

159. Table given below shows the mass number and atomic number of five elements A, B, C, D and E.

Element	Mass number	Atomic number
A	35	17
B	23	11
C	12	6
D	16	8
E	40	18

(i) To which group and period elements A, B, C, D and E. belong?
(ii) Choose from A, B, C, D and E, metal, non-metal and inert gas.
(iii) Give the electronic configurations of elements A, B, C, D and E.

Ans :
(i)

Element	Group	Period	Electronic configuration		
			K	L	M
A	17	3	2	8	7
B	1	3	2	8	1
C	14	2	2	4	
D	16	2	2	6	
E	18	3	2	8	8

(ii)

Metal	Non-metal	Inert gas
B	A	E
	C	
	D	

(iii)

Element	Electronic configuration		
	K	L	M
A	2	8	7
B	2	8	1
C	2	4	
D	2	6	
E	2	8	8

160. What were Dobereiner's triads for the classification of elements? Explain his triads for alkali metals, halogens and alkaline earth metals. Why this law could not be accepted?

Ans :
J.W. Dobereiner arranged the elements in the group of three called triads. According to this, the chemically similar elements were arranged in the increasing order of their atomic weights in the group of three to make a triad. It was noted that the atomic weight of middle element present in triad is the mean of the other two elements.
(i) Triad of alkali metals – lithium, sodium and potassium have atomic weights 7, 23 and 39 respectively. By taking the arithmetic mean of lithium and potassium we get the atomic weight of sodium, i.e. $\frac{7+39}{2} = \frac{46}{2} = 23$
(ii) Triad of halogens – chlorine, bromine and iodine have atomic weights 35.5, 80.4 and 126.5 respectively. By taking the arithmetic mean of chlorine and iodine, we get the atomic weight of bromine, i.e. $\frac{35.5+126.5}{2} = 81$
(iii) Triad of alkaline earth metals – calcium, strontium and barium have atomic weights 40, 88 and 137 respectively. By taking the arithmetic mean of calcium and barium,

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169. Rohan is given an unknown element 'X' with an atomic number of 15 by his teacher for a theoretical exercise. The teacher asks Rohan to determine the electronic configuration of this element to find its exact location within the modern periodic table. Rohan writes down the electron distribution in various shells and uses this information to predict the chemical characteristics of the element and deduce its valency with respect to hydrogen.

(a) State the electronic configuration of element 'X'.

(b) Identify the period to which element 'X' belongs.

(c) Determine the group number of element 'X' in the modern periodic table.

(d) State the valency of element 'X' with respect to hydrogen.

Ans :

(a) The electronic configuration of element 'X' is 2, 8, 5.

(b) Element 'X' belongs to Period 3 because it has three occupied electron shells.

(c) The group number of element 'X' is 15 (calculated as 5 valence electrons + 10).

(d) The valency of element 'X' with respect to hydrogen is 3.

170. Sunita is learning about historical chemistry models and comes across a classification system proposed in 18The system arranged elements in increasing order of their atomic masses, starting from hydrogen and ending at thorium. She reads that the scientist compared this chemical periodicity to the eight musical notes, observing that beryllium and magnesium resembled each other. However, she also learns that iron was placed far away from certain transition elements in this arrangement.

(a) Name the classification system Sunita is studying.

(b) State the total number of elements that were included in a single row of this classification system before the pattern repeated.

(c) Name the element after which this law was no longer truly applicable.

(d) Identify the two chemically dissimilar elements with which cobalt and nickel were grouped in this system.

Ans :

(a) Sunita is studying Newlands' Law of Octaves.

(b) In Newlands' periodic table, each row consists of a total of seven elements.

(c) The law of octaves was truly applicable only up to the element calcium.

(d) Cobalt and nickel were kept together in the same slot with fluorine, chlorine, and bromine.

171. Aditya is studying the physical properties of elements placed in the third horizontal row of the periodic table. He refers to the provided illustration to understand how the physical dimensions of atoms change as the atomic number increases progressively across a period.

A diagram showing seven circles arranged horizontally in a single straight row from left to right across the page. The circle on the far left is the largest in diameter. Moving progressively towards the right, each subsequent circle is drawn with a slightly smaller diameter than the one immediately preceding it, making the circle on the extreme right the smallest of all seven. Below each circle, there is a chemical symbol accompanied by a corresponding numerical value. From left to right, the text below the circles reads: "Na" with the number "11", "Mg" with the number "12", "Al" with the number "13", "Si" with the number "14", "P" with the number "15", "S" with the number "16", and finally "Cl" with the number "17". There are no other text labels, directional arrows, or connecting lines present between or around these circular shapes.

(a) State the specific periodic property represented by the varying sizes of the circles in the diagram.

(b) Explain the chemical reason for the gradual decrease in this property as one moves from left to right across the sequence shown.

(c) Identify the element among those shown that possesses the strongest non-metallic character.

Ans :

(a) The periodic property represented is the atomic size of the elements.

(b) 1. Moving left to right, the number of shells remains the same but the number of protons increases.
2. This increases the nuclear pull on the electrons, which decreases the size of the atom.

(c) Chlorine (Cl) possesses the strongest non-metallic character among the elements shown.

172. Neha is exploring the electronic configurations of different non-metals during her practical session. She examines the provided illustration

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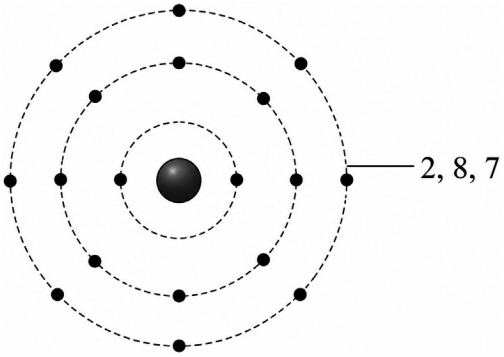
of an atom to determine its chemical family and understand how its internal electron arrangement dictates its chemical behaviour and salt-forming capabilities.

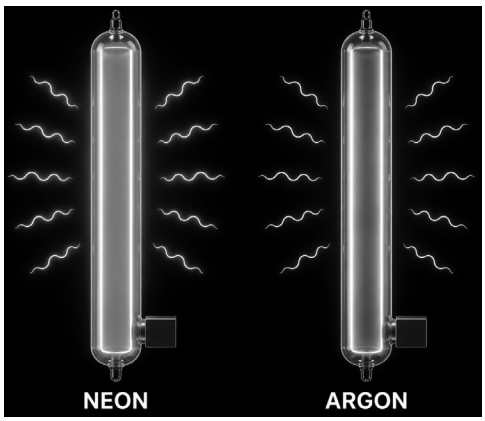


(a) Identify the group number and the specific chemical family to which the element represented in the diagram belongs.
(b) Determine the valency of this element.
(c) State what happens to the chemical reactivity of elements belonging to this specific family as one moves from top to bottom within their vertical column.

Ans :

(a) 1. The group number of the element is Group 17 (or VIIA).
2. The specific chemical family is the Halogens.
(b) The valency of this element is 1.
(c) The chemical reactivity of halogens decreases as one moves down the group from top to bottom.

173. Varun visits a commercial district at night and observes brightly coloured advertising signs made of glass tubes. His teacher explains that the glowing effect is produced when an electrical discharge passes through certain unreactive gases sealed inside the tubes. Varun looks at the provided illustration of these lighting devices.

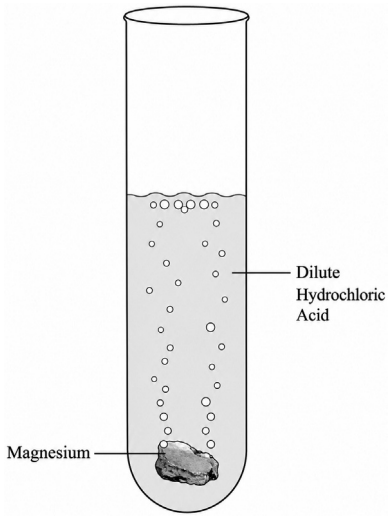


(a) Name the specific group in the modern periodic table where the two substances mentioned in the diagram are placed, and state the total number of electrons present in the outermost orbit of an argon atom.
(b) Give one reason why these substances do not generally react with other elements, and state one practical use of argon other than advertising lights.

Ans :

(a) 1. These substances are placed in Group Zero or Group 18 (Noble gases).
2. An argon atom has 8 electrons in its outermost orbit.
(b) 1. They have a stable electronic configuration with eight electrons in their outermost orbit, making them inert.
2. Argon is used to fill light bulbs because it will not react with the filament even at high temperatures.

174. Kavita is performing an experiment in the chemistry laboratory. She drops a greyish-white solid into a container filled with an acid, as depicted in the illustration. She observes rapid effervescence and notes that the solid slowly disappears while the gas escapes from the open top.



(a) Write a balanced chemical equation, including state symbols, for the specific reaction occurring between the metal and the acid shown in the diagram.
(b) State the valency of the metal shown in the diagram and identify the specific group name given to the vertical column where this metal resides in the periodic table.

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Ans :

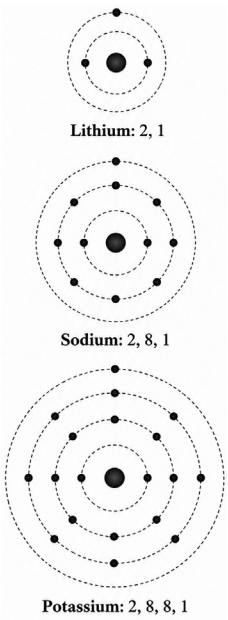
(a) 1 .

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)\uparrow$$

2. The equation must include the correct molecular formulas and balancing coefficients.

(b) 1. The valency of magnesium is 2.
2. The specific group name is the Alkaline Earth Metals (Group 2 or IIA).

175. Priya is analyzing the atomic structures of several elements provided in her textbook. She looks at the vertical arrangement of these specific atoms and observes how the internal arrangement of electron pathways changes progressively from the top illustration to the bottom illustration.



(a) State the relationship between the total number of electron shells in each atom shown and its period number in the periodic table.

(b) Based on the diagram, deduce the valency of these elements.

(c) State what happens to the size of the atoms as one moves from top to bottom through the sequence shown.

(d) Name the type of bond these elements will form when they react with non-metals.

Ans :

(a) The total number of electron shells in a given element equals the number of the period to which it belongs.

(b) The valency of all these elements is 1 because they each possess a single electron in their outermost shell.

(c) The size of the atoms increases on moving down from top to bottom due to the increase in the number of shells.

(d) These elements will form electrovalent (or ionic) bonds when they react with non-metals.

176. Manish is preparing for an examination on periodic trends. He focuses on a specific grid provided by his tutor that highlights a unique relationship between certain elements situated across adjacent vertical columns and horizontal rows.

	1	2	13	14
Period 2	Li	Be	B	C
Period 3	Na	Mg	Al	Si

(a) State the specific term used to describe the elements of the second period that show resemblance in properties with elements of the next group in the third period.

(b) Identify the chemical relationship represented by the diagonal arrows shown in the grid.

(c) Based on the grid, identify the element that shares similar properties with Beryllium (Be).

(d) State the general name given to the third-period elements Na, Mg, Al, Si, P, S, and Cl that summarise the properties of their respective groups.

Ans :

(a) Such elements of the second period are called bridge elements.

(b) The relationship represented by the arrows is called a diagonal relationship.

(c) Beryllium (Be) shares similar properties with Aluminium (Al).

(d) These third-period elements are known as typical elements.

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CHAPTER 6

Study of the First Element Hydrogen

SUMMARY

1. INTRODUCTION

Hydrogen is one of the most remarkable and fundamental elements in the universe. The first element that existed in the universe was hydrogen. It is the lightest and most abundant element in the universe, making up nearly 75% of all normal matter by mass.

1.1 Hydrogen in the Universe

Hydrogen in the Sun undergoes the process of nuclear fusion to form helium with the liberation of energy in the form of heat and light. This process is responsible for the enormous amount of energy that the Sun radiates continuously, which sustains life on Earth. Nuclear fusion of hydrogen is also the primary source of energy in all other stars present in the universe.

1.2 Discovery of Hydrogen

The credit of the discovery of hydrogen goes to Henry Cavendish, who first identified it as a distinct substance in 1766. He observed that a flammable gas was produced when metals like zinc and iron reacted with dilute acids. This gas was later studied and identified as a new element.

1.3 Naming of Hydrogen

Antoine Lavoisier, the famous French chemist, named the gas as hydrogen, which means "water producer" in Greek. He gave this name because hydrogen, when burned in air, produces water. The name is derived from two Greek words — hydro meaning water and genes meaning producer or former.

1.4 Position of Hydrogen:

Hydrogen is the first element present in the periodic table. Its atomic number is 1 and it has only one valence electron. Hence it is the member of first group and first period of the periodic table.

Hydrogen shows dual nature as it resembles both Alkali metals (group 1) and Halogens (group 17).

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1.5 Resemblance with Group 1 Elements (Alkali Metals) :

Hydrogen, although a unique element, shows a close resemblance to the alkali metals of Group 1 in many ways. The main points of resemblance between hydrogen and alkali metals are as follows:

(i) Electronic Configuration: Like alkali metals, hydrogen has also got one electron in its valence shell. Just as alkali metals have one electron in their outermost shell, hydrogen also has a single electron in its first and only shell, giving it a similar electronic behaviour.

(ii) Formation of Cations: Like alkali metals, hydrogen loses electron and forms cation.

$H - e^- \longrightarrow H^+$ (Hydrogen)

$Na - e^- \longrightarrow Na^+$ (Alkali metal)

Just as alkali metals lose their valence electron to form positively charged ions, hydrogen also loses its single electron to form a positively charged hydrogen ion (H^+), also known as a proton.

(iii) Formation of Compounds: Hydrogen readily forms stable compounds with oxygen, sulphur and chlorine.

H_2O = Water

H_2S = Hydrogen sulphide

HCL = Hydrogen chloride

In the similar way, the alkali metals form oxides, sulphides and chlorides

Na_2O = Sodium oxide

Na_2S = Sodium sulphide

NaCI = Sodium chloride

This similarity in the type of compounds formed further establishes the resemblance between hydrogen and alkali metals.

(iv) Combustion in Oxygen:
Hydrogen burns in oxygen to form water (neutral oxide).

$$2H_2 + O_2 \longrightarrow 2H_2O.$$

1.6 Resemblance of Hydrogen with Group 17 Elements (Halogens)

Hydrogen resembles halogens in the following ways:

(i) Electronic Configuration: Both hydrogen and halogen require one electron to complete their duplet and octet respectively, hence they gain electrons to acquire stable configuration. Therefore, they are electronegative and mono- valent.

$$\underset{1}{H} + e^- \longrightarrow \underset{2}{H^-}$$

$$\underset{2,8,7}{Cl} + e^- \longrightarrow \underset{2,8,8}{Cl^-}$$

(ii) Atomicity: It is the number of atoms present in one molecule of an element. Both hydrogen and halogens are diatomic, i.e. having two atoms in its one molecule.
Hydrogen — H_2
Fluorine — F_2
Chlorine — Cl_2
Bromine — Br_2
Iodine — I_2

2. ISOTOPES OF HYDROGEN:

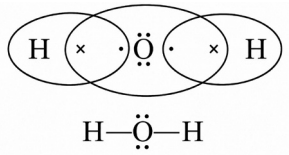
Hydrogen has three isotopes, i.e. these are the atoms of same element having same atomic number but different mass number.
Isotopes differ in number of neutrons.

Name of the Isotopes	Symbol	Mass Number	Atomic Number	Protons	Neutrons	Electrons
Protium	${}^{1}_{1}H$	1	1	1	0	1
Deuterium	${}^{2}_{1}D$ or ${}^{2}_{1}H$	2	1	1	1	1
Tritium	${}^{3}_{1}T$ or ${}^{3}_{1}H$	3	1	1	2	1

2.1 Occurrence of Hydrogen

Hydrogen occurs in free state as well as in combined state. It is not much abundant on the earth. It is found in traces of the earth crust and in the atmosphere.

Hydrogen in combined state occurs in the form of water (H_2O). Water is a polar covalent compound.
All plants and animals have hydrogen in the form of carbohydrates, fats and proteins.
Organic compounds essentially contain hydrogen in combination with carbon.



Formation of polar covalent bond in water.

2.2 General Methods of Preparation of Hydrogen:

(i) By action of metals with cold water: Sodium, potassium and calcium react with cold water to form its respective metallic hydroxides (soluble) with the liberation of hydrogen. It is not a safe method to prepare hydrogen gas in laboratory as the reaction sometimes proceeds wian explosion.

Metal + Cold water
$\longrightarrow$ Metal hydroxide + Hydrogen

$$\underset{\text{Sodium}}{2Na} + \underset{\text{Water}}{2H_2O} \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH} + \underset{\text{Hydrogen}}{H_2}$$

$$\underset{\text{Potassium}}{2K} + \underset{\text{Water}}{2H_2O} \longrightarrow \underset{\text{Potassium hydroxide}}{2KOH} + \underset{\text{Hydrogen}}{H_2}$$

$$\underset{\text{Calcium}}{Ca} + \underset{\text{Water}}{2H_2O} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Hydrogen}}{H_2}$$

Both sodium and potassium react vigorously with cold water. The solution thus produced as a result of reaction turns red litmus blue showing that the solution formed is basic or alkaline in nature.

(ii) By the reaction of metals with steam:

Heated + Steam $\longrightarrow$ Metalic oxide + Hydrogen

$$Mg + \underset{\text{Steam}}{H_2O} \longrightarrow MgO + H_2$$

$$2Al + 3H_2O \longrightarrow Al_2O_3 + 3H_2$$

$$Zn + \underset{\text{Steam}}{H_2O} \longrightarrow Zno + H_2$$

$$\underset{\text{(Hot)}}{3Fe} + \underset{\text{Steam}}{4H_2O} \rightleftharpoons Fe_3O_4 + 4H_2$$

(iii) By the reaction of dilute acids with active metals:

(a) Activity series: The series in which the metals are arranged in the decreasing order of their reactivity is called activity series.

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(f) A colourless liquid collects in the conical flask, which is placed in ice cold water, which helps in the condensation of water vapour. This colourless liquid turns anhydrous copper sulphate from white to blue.

6. TESTS FOR HYDROGEN

In order to identify the presence of hydrogen gas, certain standard tests are performed. These tests are based on the unique physical and chemical properties of hydrogen. The following are the two most commonly used tests for the identification of hydrogen gas:

(i) Hydrogen gas burns with a popping sound.

(ii) Hydrogen burns in air with pale blue flame to form colourless liquid water, which turns anhydrous copper sulphate from white to blue.

6.1 Redox Reaction

In many chemical reactions, oxidation and reduction do not occur independently but always take place together at the same time. The reaction in which oxidation and reduction take place simultaneously is called a redox reaction. The term "redox" is a combination of two words — red from reduction and ox from oxidation. In a redox reaction, one substance loses electrons (gets oxidized) while the other substance gains electrons (gets reduced). The substance that loses electrons is called the reducing agent and the substance that gains electrons is called the oxidizing agent.

6.2 Oxidation

Oxidation is a chemical change which involves the addition of oxygen or addition of electronegative element or ion to a substance.

(i) Addition of Oxygen to Element or Compound:

(a) Magnesium is oxidized to magnesium oxide

$$2Mg + O_2 \longrightarrow 2MgO$$

(b) Copper is oxidized to copper oxide

$$2Cu + O_2 \longrightarrow 2CuO$$

(c) Carbon monoxide is oxidized to carbon dioxide

$$2CO + O_2 \longrightarrow 2CO_2$$

(d) Nitrogen monoxide or Nitric oxide is oxidised to nitrogen dioxide.

$$2NO + O_2 \longrightarrow 2NO_2$$

(ii) Addition of Electronegative Element or Ion:

$$2FeCl_2 + Cl_2 \longrightarrow 2FeCl_3$$

Oxidation can also be defined as the removal of hydrogen or the electropositive element or ion from a substance.

$$H_2S + Cl_2 \longrightarrow 2HCL + S$$

6.3 Oxidizing agents

In a chemical reaction, the substances which bring about the process of oxidation are called oxidizing agents. An oxidizing agent is itself reduced during the reaction, as it accepts electrons from the substance being oxidized. In other words, an oxidizing agent gains electrons while causing another substance to lose them. Examples of oxidizing agents are:

(i) Solid —

Potassium permanganate	$KMnO_4$
Potassium dichromate	$K_2Cr_2O_7$
Lead dioxide	PbO_2
Red lead	$Pb3O_4$
Copper oxide	CuO

(ii) Liquid — Concentrated nitric acid
Concentrated sulphuric acid

(iii) Gases — Chlorine
Sulphur dioxide
Oxygen

6.4 Reduction

Reduction is a chemical change which involves either the addition of hydrogen or electropositive element to the substance or it involves the removal of oxygen or electronegative element from the substance.

(i) Addition of hydrogen:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

$$H_2S + Cl_2 \longrightarrow 2HCL + S$$

(iii) Removal of oxygen:

$$ZnO + H_2 \longrightarrow Zn + H_2O$$

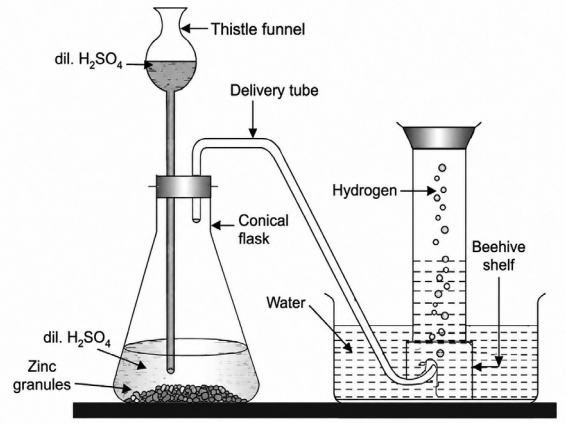
$$CuO + C \longrightarrow Cu + CO$$

6.5 Reducing Agents

In a chemical reaction, the substances which bring about the process of reduction are called reducing agents or reductants. A reducing agent is itself oxidized during the reaction, as it donates electrons or hydrogen to the substance being reduced. In other words, a reducing agent loses electrons while causing another substance to gain them. Examples of reducing agents

Aluminium gets coated with the thin but tough layer of oxide which prevents the reaction of metal with water and dilute acids.

In iron, the liberation of hydrogen is very slow and as copper lies below hydrogen in activity series so, it cannot displace hydrogen from dilute acids.



Laboratory preparation of Hydrogen from Granulated zinc and dil. H_2SO_4

(ii) The apparatus used for the preparation of hydrogen gas should be airtight. The lower end of the thistle funnel should dip in the acid otherwise the gas will escape from the thistle funnel. The apparatus should be kept away from the flame.

3.2 Impurities in Hydrogen

Hydrogen obtained by the reaction of granulated zinc with dilute sulphuric acid is not pure, it contains the impurities of the following gases:

(a) Sulphur dioxide — SO_2
(b) Carbon dioxide — CO_2
(c) Water vapour — H_2O
(d) Hydrogen sulphide — H_2S
(e) Arsine — AsH_3
(f) Phosphine — PH_3
(g) Nitrogen dioxide — NO_2

Although pure hydrogen is odourless but because of the presence of the preceded mentioned gases as impurities it possesses a characteristic peculiar odour.

3.3 Purification of Hydrogen

For the purification of hydrogen, the impure gas is passed through

(a) Silver nitrate solution: To absorb arsine and phosphine.
(b) Lead nitrate solution: To absorb hydrogen sulphide.
(c) Potassium hydroxide solution: To absorb carbon dioxide, sulphur dioxide and nitrogen dioxide.
(d) Anhydrous calcium chloride: To absorb moisture.

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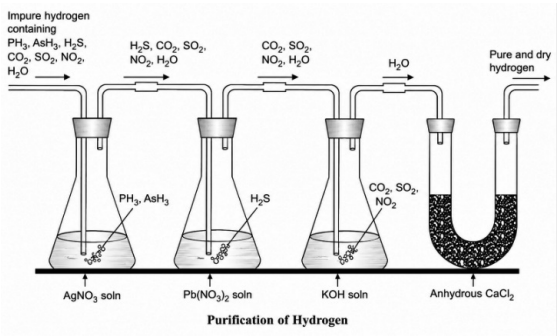

Purification of Hydrogen

Hydrogen prepared is collected by the downward displacement of water, after first allowing the air to escape, as air forms an explosive mixture with hydrogen. Hydrogen collected is dried by passing through anhydrous calcium chloride.

4. INDUSTRIAL MANUFACTURE OF HYDROGEN

Industrially, hydrogen is manufactured by the following methods:

(a) By the electrolysis of acidulated water with platinum electrodes:

When electricity is passed through acidulated water then hydrogen gas is obtained at cathode and oxygen gas is obtained at anode.

$$H_2O \longrightarrow H^+ + OH^-$$

$$HCL \longrightarrow H^+ + Cl^-$$

At cathode $\quad H^+ + e^- \longrightarrow [H]$

$$2[H] \longrightarrow [H_2]$$

At anode $\quad OH^- - e^- \longrightarrow OH$

$$4OH \longrightarrow 2H_2O + O_2$$

(b) By Bosch Process: This process involves the following two steps :

(i) Preparation of water gas: When superheated steam at a temperature of 170 °C is passed over white hot charcoal, it forms equivolume mixture of carbon monoxide and hydrogen called water gas. The reaction for the formation of water gas is endothermic in nature.

$$\underset{\text{White hot charcoal}}{C} + \underset{\text{Super heated steam}}{H_2O} \xrightarrow{170\,^\circ C} \underset{\text{Water gas}}{CO + H_2}$$

(ii) Removal of impurities (carbon monoxide) from water. gas:
Water gas formed is mixed with twice the volume of steam and passed over the catalyst, which is a mixture of ferric oxide and chromium oxide (promoter) at a temperature of 450 °C, carbon monoxide gets oxidized to carbon dioxide.

$$\underbrace{CO + H_2}_{\text{Water gas}} + H_2O \xrightarrow[450^\circ C]{Fe_2O_3/Cr_2O_3} 2H_2 + CO_2$$

The above reaction is called the water gas shift reaction.
The hydrogen obtained by this process contains the impurities of carbon monoxide in traces and carbon dioxide. Carbon monoxide can be removed by passing it through ammoniacal cuprous chloride solution. Carbon dioxide can be removed by passing through cold water under pressure.

4.1 Physical properties of Hydrogen:

Physical properties of Hydrogen are as follows :
(i) Pure hydrogen is a colourless, odourless and tasteless gas. However, impure hydrogen has fishy smell.
(ii) Hydrogen is the lightest gas.
(iii) Hydrogen is practically insoluble in water.

4.2 Chemical properties of Hydrogen

The chemical properties of the hydrogen are as follows :
(i) Combustibility: Hydrogen is a combustible gas but it is not a supporter of combustion. It burns with pale blue flame. If hydrogen is mixed with air or oxygen and then ignited, it causes explosion.
(ii) Action towards litmus: Hydrogen is neutral towards litmus. In other words, it neither turns red litmus to blue nor blue litmus to red, i.e. it is neither acidic nor basic in nature.
(iii) Action with non-metals:
(a) Reaction with Oxygen: It burns silently in the atmosphere of oxygen with pale blue flame to form water, i.e. the product of oxidation of hydrogen is water.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

(b) Reaction with Nitrogen: The process of manufacturing or synthesis of ammonia from its elements is called Haber's process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{heat}$$

Catalyst — Finely divided Iron
Promoter — Molybdenum
Temperature — $450 - 500^\circ C$
Pressure — $200 - 1000$ atm.

(c) Reaction with Chlorine: Chlorine has maximum affinity for hydrogen. It readily reacts with hydrogen in diffused sunlight to form hydrogen chloride gas. This reaction does not take place in dark, however, in direct sunlight the reaction proceeds spontaneously with an explosion to form hydrogen chloride gas.

$$H_2 + Cl_2 \xrightarrow[\text{sunlight}]{\text{diffused}} 2HCL$$

(d) Reaction with Sulphur : When hydrogen gas is passed through boiling sulphur, it form a gas having rotten egg smell.

$$H_2 + \underset{\text{boiling}}{S} \longrightarrow \underset{\text{Hydrogen sulphide}}{H_2S}$$

(iv) Reaction with Metals: Metals like sodium, potassium and calcium on heating with dry hydrogen form their respective hydrides. The hydrides formed are unstable and react with cold water to form their respective soluble hydroxide and hydrogen gas.

$$2Na + H_2 \xrightarrow{\Delta} \underset{\text{(Sodium hydride)}}{2NaH}$$

$$2K + H_2 \xrightarrow{\Delta} \underset{\text{(Potassium hydride)}}{2KH}$$

$$Ca + H_2 \xrightarrow{\Delta} \underset{\text{(Calcium hydride)}}{CaH_2}$$

$$NaH + H_2O \longrightarrow NaOH + H_2$$

$$KH + H_2O \longrightarrow KOH + H_2$$

$$CaH_2 + 2H_2O \longrightarrow Ca(OH)_2 + 2H_2$$

(v) Reducing property of Hydrogen:
(a) When hydrogen gas is passed over heated oxides of lead, copper and zinc, the metallic oxides get reduced to their respective metals and hydrogen gets oxidized to water.

$$\underset{\text{(hot)}}{PbO} + H_2 \longrightarrow Pb + H_2O$$

$$\underset{\text{(hot)}}{CuO} + H_2 \longrightarrow Cu + H_2O$$

$$\underset{\text{(hot)}}{ZnO} + H_2 \longrightarrow Zn + H_2O$$

(b) Nascent hydrogen is a powerful reducing agent as compared to molecular hydrogen.
(c) Hydrogen which is formed at the time of its formation is called nascent hydrogen and is very short-lived, i.e. it immediately gives molecular hydrogen.

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(d) Nascent hydrogen is prepared 'in situ', i.e. at the time of reaction within the reaction medium.

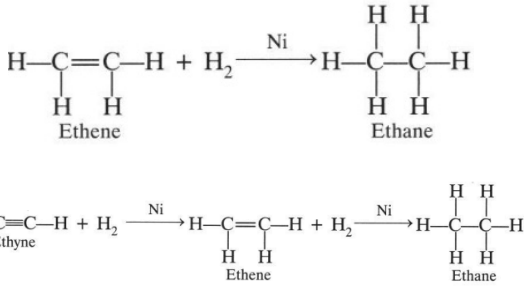
(e) The pale yellow ferric chloride solution when mixed with dilute hydrochloric acid and zinc dust, turns pale green, as ferric chloride gets reduced to ferrous chloride by the nascent hydrogen which is produced by the reaction of zinc dust and dilute hydrochloric acid.

$$Zn + 2HCL \longrightarrow ZnCl_2 + 2[H]$$

$$\underset{\text{Yellow solution}}{FeCl_3} + [H] \longrightarrow \underset{\text{Pale green}}{FeCl_2} + HCL$$

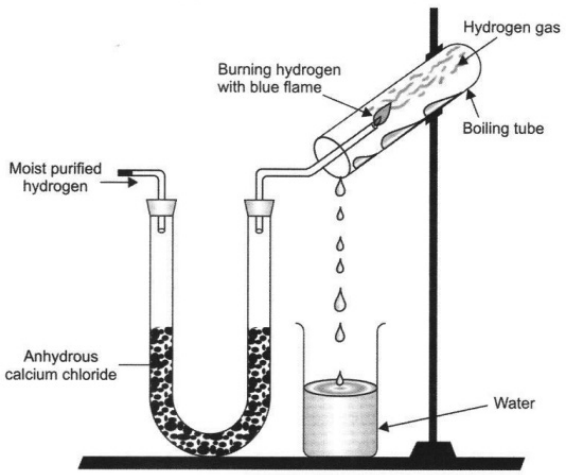
(vi) Hydrogenation: It is the process of addition of hydrogen to alkenes and alkynes in the presence of nickel as a catalyst. In this process, the unsaturated hydrocarbon gets converted to saturated hydrocarbon.

$$C_2H_4 + H_2 \xrightarrow{Ni} C_2H_6$$



5. IMPORTANT EXPERIMENTS TO DEMONSTRATE THE PROPERTIES OF HYDROGEN:

(i) To demonstrate that water is the only product formed during combustion of hydrogen in air :



Oxidation of Hydrogen and Formation of Water

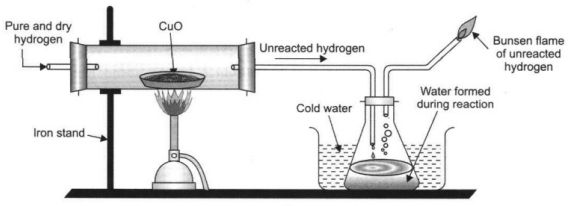
(a) Pure hydrogen is passed through anhydrous calcium chloride (drying agent). The pure dry gas is burnt from the jet and the flame is either allowed to strike the cold surface of glass retort or the flame is allowed to burn in wide glass boiling tube.

(b) In a few moments a colourless liquid starts trickling down from the sides of the boiling tube and get collected in the beaker placed below.

(c) The colourless liquid is water and it can be tested as

1. Water turns anhydrous copper sulphate from white to blue.
2. Water turns anhydrous cobalt chloride from blue to pink.

(ii) To demonstrate that hydrogen reduces copper oxide to copper metal:



Reduction of Copper Oxide to Copper Metal.

Reduction of Copper Oxide to Copper Metal.

(a) Take a hard glass tube opened from both the ends and in the middle of the tube, place black coloured copper oxide. Heat copper oxide present in the centre with the non-luminous bunsen flame as shown in figure.

(b) Now pass pure dry hydrogen over heated copper oxide.

(c) Light a flame on the jet tube so as to burn the unreacted hydrogen. Continue passing hydrogen, till the flame at the end of jet tube grows bigger in size. This clearly indicates that the reaction has completed and the hydrogen gas is not taking part in the reaction.

(d) The source of heating is removed, but the hydrogen gas is continued to pass, till the temperature of the tube comes down to the room temperature.

(e) The black colour of copper oxide slowly changes to pinkish red as copper oxide has reduced to copper metal.

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reasoning is factually incorrect because these elements only need a single electron, not two, to successfully achieve the stable electronic configuration of their closest noble gas.

5. Which specific physical or chemical characteristic uniquely distinguishes hydrogen from both the alkali metal group and the halogen group?
(A) It naturally forms stable diatomic molecules.
(B) It consistently acts as a chemical reducing agent.
(C) Its atomic structure contains only one electron shell.
(D) It regularly exhibits strong electronegative character.

Ans : (C)

While alkali metals and halogens possess multiple electron shells in their atomic structures, the hydrogen atom is entirely unique because it contains merely a single electron shell. Additionally, the oxide formed by hydrogen is perfectly neutral, unlike the other groups.

6. Who is primarily credited with the official discovery of hydrogen by successfully establishing its elementary nature and demonstrating that water is produced when it burns in air?
(A) Robert Boyle
(B) Paracelsus
(C) Henry Cavendish
(D) Antoine Lavoisier

Ans : (C)

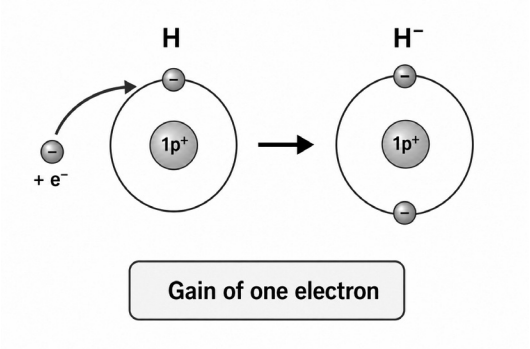
Although several early scientists observed the gas during various chemical reactions, Henry Cavendish officially discovered hydrogen in seventeen sixty-six. He proved its elementary nature and accurately demonstrated that its combustion in atmospheric air results directly in the formation of water.

7. Antoine Lavoisier officially named the newly discovered gas "hydrogen" in 17What is the fundamental scientific meaning of this specific Greek term?
(A) Acid former
(B) Water former
(C) Gas producer
(D) Salt former

Ans : (B)

Antoine Lavoisier coined the specific term hydrogen from Greek roots because this highly combustible gas distinctly produces water upon burning. The precise literal translation of this ancient Greek scientific designation explicitly signifies the vital concept of being a water former.

8. The diagram illustrates an alternative process for a hydrogen atom, showing its resemblance to Group 17 (VIIA) elements. What characteristic is depicted?



(A) Formation of a cation
(B) Formation of an anion
(C) Its electropositive character
(D) Its reaction with non-metals

Ans : (B)

The diagram depicts a hydrogen atom gaining one electron to complete its valence shell, thereby forming a negatively charged hydride ion (H^-). This process is the formation of an anion. This behaviour is similar to that of halogens like chlorine and fluorine, which also gain one electron to achieve a stable noble gas configuration.

9. Which of the following statements concerning the natural occurrence and cosmic distribution of hydrogen is entirely incorrect?
(A) It appears to be the most abundant element in the universe.
(B) Earth's lower atmosphere contains approximately ten percent free hydrogen.
(C) Most main-sequence stars are predominantly composed of hydrogen gas.
(D) It remains a characteristic constituent of acids, alkalis, and organic proteins.

Ans : (B)

Hydrogen is highly abundant across the universe and within celestial bodies. However, it exists only in minute trace amounts within the Earth's atmosphere, constituting approximately zero point zero one percent, rather than ten percent, of the total atmospheric gas composition.

10. Consider the following statements regarding the chemical reaction of potassium metal with cold water

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are carbon, carbon monoxide, sulphur dioxide, hydrogen iodide, etc.

6.6 Uses of Hydrogen:

Hydrogen is one of the most versatile and useful elements known to mankind. Due to its unique physical and chemical properties such as being the lightest gas, highly combustible and a powerful reducing agent, hydrogen finds a wide range of applications in everyday life as well as in various industries. The important uses of hydrogen are as follows:

(i) as a fuel.
(ii) as a reducing agent in metallurgy.
(iii) for hydrogenation of oils to ghee.
(iv) for welding and cutting of metals.

OBJECTIVE QUESTIONS

1. Hydrogen has one valence electron, similar to alkali metals, but requires one more to complete its shell, similar to halogens. Because of this electronic configuration, what is the nature of hydrogen's position in the periodic table?

(A) It strictly belongs only to the alkali metals group.
(B) It strictly belongs only to the halogens group.
(C) It is considered a transition metal.
(D) It exhibits a dual nature resembling both alkali metals and halogens.

Ans : (D)

Hydrogen has one valence electron, aligning it with alkali metals. However, it requires one more electron to achieve the stable doublet configuration of helium, resembling halogens. Consequently, it exhibits a dual nature, sharing distinct chemical properties with both groups.

2. Consider the following statements regarding the similarities between hydrogen and alkali metals

I. Both possess exactly one valence electron.
II. Both naturally form anions by gaining an electron.
III. Both behave as strong chemical reducing agents.
IV. Both exist exclusively as solid metals at room temperature.

Which of the above statements are correct?

(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

Ans : (B)

Hydrogen and alkali metals possess a single electron in their outermost shell and exhibit strong reducing properties. Unlike alkali metals, hydrogen is a gaseous non-metal under standard environmental conditions and typically forms positive ions by losing its sole valence electron.

3. The reactions of three different metals with cold water were observed and recorded as shown below. The observation for Metal X was not recorded.

Metal	Density relative to water	Vigour of Reaction	Flame Observed
Potassium (K)	Floats	Very high	Lilac
Sodium (Na)	Floats	High	Golden-yellow
Calcium (Ca)	Sinks	Moderate	X

Based on the decreasing reactivity trend from K to Ca, what would observation 'X' for Calcium's reaction be?

(A) Burns with a brick-red flame.
(B) Burns with a pale blue flame.
(C) Does not catch fire.
(D) Does not react with cold water.

Ans : (C)

The reactivity of metals with cold water decreases down the series from Potassium to Calcium. While Potassium and Sodium are reactive enough to catch fire, the reaction of Calcium with cold water is less vigorous and not exothermic enough to ignite the hydrogen gas produced. Therefore, no flame is observed.

4. Assertion Hydrogen and halogens exist as diatomic molecules in their standard elemental states.
Reason Both hydrogen and halogens require two electrons to attain the stable electronic configuration of the nearest noble gas.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Hydrogen and halogens naturally form diatomic molecules like H_2, F_2, and Cl_2. However, the

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K	Potassium	Reactivity Increases ↑	Reactivity Decreases ↓
Ca	Calcium		
Na	Sodium		
Mg	Magnesium		
Al	Aluminium		
Zn	Zinc		
Fe	Iron		
Pb	Lead		
[H]	Hydrogen		
Cu	Copper		
Hg	Mercury		
Ag	Silver		
Au	Gold		
Pt	Platinum		

(b) The metal lying at the top is the most reactive metal and the metal present at the bottom is the least reactive metal.

(c) The metals placed above hydrogen are called active metals as they can displace hydrogen readily from water and dilute acids.

(d) Highly reactive metals like sodium, potassium and calcium react vigorously at ordinary temperature with dilute acids liberating hydrogen.

$$2Na + \underset{dil}{2HCL} \longrightarrow 2NaCl + H_2$$

$$2K + \underset{dil}{2HCL} \longrightarrow 2KCl + H_2$$

$$Ca + \underset{dil}{2HCL} \longrightarrow CaCl_2 + H_2$$

(e) Metals like magnesium, zinc, aluminium, iron, etc. react moderately at ordinary temperature with dilute acids to form salt and liberate hydrogen.

$$\text{Metal} + \text{Dil. acid} \longrightarrow \text{Salt} + \text{Hyd...}$$

$$Mg + \underset{dil}{2HCL} \longrightarrow MgCl_2 + H_2$$

$$Mg + \underset{dil}{H_2SO_4} \longrightarrow MgSO_4 + H_2$$

$$Zn + \underset{dil}{2HCL} \longrightarrow ZnCl_2 + H_2$$

$$Zn + \underset{dil}{H_2SO_4} \longrightarrow ZnSO_4 + H_2$$

$$2Al + \underset{dil}{6HCL} \longrightarrow 2AlCl_3 + 3H_2$$

$$2Al + \underset{dil}{3H_2SO_4} \longrightarrow Al2(SO_4)_3 + 3H_2$$

$$Fe + \underset{dil}{2HCL} \longrightarrow FeCl_2 + H_2$$

$$Fe + \underset{dil}{H_2SO_4} \longrightarrow FeCl_2 + H_2$$

(f) Nitric acid reacts with only magnesium and manganese to liberate hydrogen. With rest of the metals it produces oxides of nitrogen or ammonium nitrate and not hydrogen as it is an oxidising agent.

$$Mg + \underset{V.dil}{2HNO_3} \longrightarrow Mg(NO_3)_2 + H_2$$

$$Mn + \underset{V.dil}{2HNO_3} \longrightarrow Mg(NO_3)_2 + H_2$$

(g) Lead is not used for the preparation of hydrogen by using dilute hydrochloric acid and dilute sulphuric acid because the products are insoluble lead chloride and lead sulphate which settle on fresh lead metal and thus, prevents the reaction of metal with acid.

(iv) By the action of alkalies with metals: Metals like zinc, aluminium and lead in powder form dissolve when boiled with concentrated sodium hydroxide or concentrated potassium hydroxide to form their respective soluble complex salts with the liberation of hydrogen.

$$Zn + \underset{conc.}{2NaOH} \xrightarrow{boiled} \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2$$

$$Zn + \underset{conc.}{2KOH} \xrightarrow{boiled} \underset{\text{Potassium zincate}}{K_2ZnO_2} + H_2$$

$$2Al + \underset{conc.}{2NaOH + 2H_2O} \xrightarrow{boiled} \underset{\text{Sodium aluminate}}{2NaAlO_2} + 3H_2$$

$$2Al + \underset{conc.}{2KOH + 2H_2O} \xrightarrow{boiled} \underset{\text{Potassium aluminate}}{2KAlO_2} + 3H_2$$

$$Pb + \underset{conc.}{2NaOH} \xrightarrow{boiled} \underset{\text{Sodium plumbate}}{Na_2PbO_2} + H_2$$

3. LABORATORY PREPARATION OF HYDROGEN

In laboratory, hydrogen is prepared by the reaction of dilute sulphuric acid with granulated zinc.

$$Zn + \underset{dil.}{H_2SO_4} \longrightarrow ZnSO_4 + H_2$$

3.1 Reasons for Using Zinc

(i) Zinc is preferred to other metals because sodium and potassium react explosively or violently with cold water or dilute acids. In calcium and magnesium, the liberation of hydrogen is so rapid that it cannot be collected.

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I. The solid potassium metal sinks completely to the bottom.
II. The chemical reaction is highly exothermic and extremely vigorous.
III. The reacting metal catches fire and visibly burns with a lilac flame.
IV. The resulting aqueous solution produced is chemically acidic in nature.

Which of the statements are accurate?
(A) I and II
(B) II and III
(C) III and IV
(D) I and IV

Ans : (B)

Potassium possesses a density lower than water, causing it to float on the surface rather than sink. Its reaction is vigorously exothermic, igniting the evolved gas with a characteristic lilac flame, and producing an alkaline solution of potassium hydroxide.

11. The following table, based on the activity series, describes the conditions under which certain metals react with water to produce hydrogen gas.

Metal Group	**Metals**	**Reaction with Water**
1	K, Na, Ca	Displace H_2 from cold water.
2	Mg, Al, Zn, Fe	Decompose boiling water or steam.
3	Cu, Hg, Ag, Au	X

What does 'X' represent for the metals in Group 3?
(A) Displace H_2 from cold water slowly.
(B) Displace H_2 only from steam at very high temperatures.
(C) Do not displace H_2 from water or steam.
(D) Displace H_2 only when an acid is added.

Ans :(C)

The metals in Group 3 (Copper, Mercury, Silver, Gold) are located below hydrogen in the activity series. This position signifies that they are less reactive than hydrogen and lack the ability to displace it from water, regardless of whether the water is cold, boiling, or in the form of steam.

12. Assertion Sodium amalgam reacts very smoothly with cold water and is therefore considered safe to use for laboratory hydrogen preparation.
Reason Alloying sodium metal with mercury drastically increases the violently exothermic nature of its reaction with water.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Sodium amalgam is an alloy of sodium and mercury that reacts quite smoothly with water, ensuring safety during laboratory hydrogen preparation. The reasoning is incorrect because the specific purpose of the amalgam is to decrease, not increase, the reaction's vigor.

13. Assertion Aluminium metal initially reacts with steam to successfully liberate hydrogen gas, but soon the chemical reaction stops entirely.
Reason A passive coating of aluminium oxide quickly forms on the metal surface, permanently preventing any further reaction.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Aluminium vigorously attacks steam initially, but this chemical interaction quickly halts. The exposed surface develops a highly adherent, protective layer of aluminium oxide. This passive coating effectively shields the underlying metal, completely preventing any further decomposition of the steam.

14. When solid calcium is dropped into a beaker of cold water, the surrounding solution eventually turns milky and turbid. What is the specific chemical reason for this distinct visual observation?
(A) Formation of highly soluble calcium oxide
(B) Formation of sparingly soluble calcium hydroxide
(C) Rapid evolution of extremely dense hydrogen gas bubbles
(D) Instant precipitation of completely unreacted calcium metal powder

Ans : (B)

Calcium reacts steadily with cold water, sinking and releasing hydrogen gas bubbles. This chemical process generates calcium hydroxide, an alkaline substance that is only sparingly soluble in water,

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(D) By passing the entire gas slowly through a highly concentrated lead nitrate chemical solution

Ans : (A)

After initially removing carbon dioxide, residual traces of unreacted carbon monoxide stubbornly remain. These are entirely eliminated by scrubbing the gaseous mixture through a specialized solution of ammoniacal cupric chloride, which selectively dissolves carbon monoxide to form an addition compound.

41. The Bosch process for the industrial manufacture of hydrogen involves two main stages. A simplified summary is given in the table.

Stage	1	2
Reactants	Coke (C) + Steam	$(CO + H_2)$ + Steam
Catalyst	-	Fe_2O_3 (Catalyst) + X (Promoter)
Temperature	1000°C	450°C
Products	$CO + H_2$ (Water gas)	$CO_2 + 2H_2$

Identify the substance 'X' which acts as a promoter in the second stage of the Bosch process.

(A) Nickel (Ni)
(B) Chromic oxide (Cr_2O_3)
(C) Manganese dioxide (MnO_2)
(D) Vanadium pentoxide (V_2O_5)

Ans : (B)

In the second stage of the Bosch process, the catalyst used is ferric oxide (Fe_2O_3). To increase the efficiency and activity of this catalyst, a promoter is used. The specific promoter employed in this water-gas shift reaction is chromic oxide (Cr_2O_3), which enhances the catalytic performance of ferric oxide.

42. During the standard electrochemical electrolysis of acidulated water, which distinct elemental gases are reliably evolved at the respective designated electrodes?

(A) Hydrogen gas at the anode and Oxygen gas at the cathode
(B) Oxygen gas at the anode and Hydrogen gas at the cathode
(C) Both Hydrogen and Oxygen gases strictly simultaneously at the cathode
(D) Both Hydrogen and Oxygen gases strictly simultaneously at the anode

Ans : (B)

When electrical current thoroughly traverses acidulated water, positively charged hydrogen ions naturally migrate directly toward the negatively charged cathode, liberating hydrogen gas. Conversely, negatively charged hydroxide ions systematically move toward the positive anode, actively discharging to produce pure oxygen gas.

43. Which of the following precisely stated descriptors is strictly NOT a genuine true physical property of pure molecular hydrogen gas?

(A) It is fundamentally completely colourless, odourless, and thoroughly tasteless.
(B) It is exceptionally highly toxic and acutely poisonous if inhaled even in small amounts.
(C) It is definitively the absolute lightest known gas with a standard density of 0.0899 g/mL.
(D) It is only very slightly chemically soluble in pure distilled liquid water.

Ans : (B)

Hydrogen possesses remarkable physical characteristics, being the absolute lightest known elemental substance, entirely colorless, and essentially insoluble in aqueous solutions. Crucially, it is fundamentally completely non-toxic and absolutely non-poisonous, contrary to the entirely false assertion presented in the incorrect option.

44. When highly pure hydrogen gas strictly burns completely quietly in open atmospheric air, what is the exact visual color of the resulting flame, and what specific chemical product is directly formed?

(A) Yellow flame, steadily forming gaseous carbon dioxide
(B) Pale blue flame, steadily forming liquid water
(C) Lilac flame, steadily forming liquid hydrogen peroxide
(D) Intense white flame, steadily forming liquid water

Ans : (B)

Pure molecular hydrogen readily undergoes quiet combustion when ignited in atmospheric air. During this highly exothermic chemical reaction, it continuously burns with a characteristic, barely visible pale blue flame, smoothly combining with atmospheric oxygen to exclusively produce liquid water.

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color change of this specific metal oxide?
(A) White when hot, yellow when cold
(B) Yellow when hot, white when cold
(C) Brown when hot, grey when cold
(D) Black when hot, red when cold

Ans : (B)

Zinc requires significant heating to react with steam, successfully liberating hydrogen gas and forming zinc oxide. A unique physical property of this specific metallic oxide is its distinct thermochromic nature, appearing bright yellow when hot and turning white upon cooling.

20. An analyst prepared a table to compare the electronic configuration of hydrogen with elements from Group 1A and Group 17.

Element	Atomic Number	Electronic Configuration
Hydrogen (H)	1	1
Lithium (Li)	3	2, 1
Fluorine (F)	9	2, 7
Sodium (Na)	11	2, 8, 1

Based on the table, what is the primary reason for placing hydrogen with alkali metals like Lithium and Sodium in the periodic table?
(A) They all have only one shell.
(B) They all have one valence electron.
(C) They are all gases at room temperature.
(D) They all have the same atomic number.

Ans : (B)

The table shows that hydrogen, lithium, and sodium each have one electron in their outermost shell (valence shell). This similarity in electronic configuration is the fundamental reason for grouping hydrogen with alkali metals in Group 1A. The number of shells, physical state, and atomic numbers are different for these elements.

21. Match the specific reactants listed in List-I with their corresponding chemical products listed in List-II regarding the action of water or steam.
List-I (Reactants)
P. Red hot coke + Steam
Q. Cold water + Potassium
R. Boiling water + Magnesium
S. Steam + Iron
List-II (Products)
I. Triferric tetroxide + Hydrogen
II. Water gas ($CO + H_2$)
III. Potassium hydroxide + Hydrogen
IV. Magnesium hydroxide + Hydrogen
(A) P-II, Q-III, R-IV, S-I
(B) P-II, Q-IV, R-III, S-I
(C) P-I, Q-III, R-II, S-IV
(D) P-III, Q-I, R-IV, S-II

Ans : (A)

Passing steam over intensely heated carbon produces water gas, a valuable industrial mixture. Potassium actively violently attacks cold water yielding its hydroxide. Boiling water slowly transforms magnesium into its hydroxide, while steam reacts reversibly with heated iron yielding triferric tetroxide.

22. The activity series arranges metals strictly based on their relative chemical reactivity. Which of the following groups contains specific metals that do NOT naturally displace hydrogen from dilute mineral acids under normal conditions?
(A) Mg, Al, Zn
(B) Cu, Ag, Au
(C) K, Na, Ca
(D) Fe, Ni, Sn

Ans : (B)

The activity series organizes metals strictly by their chemical reactivity. Elements positioned securely below hydrogen, specifically including copper, silver, mercury, and gold, completely lack the necessary reducing strength to displace hydrogen gas from standard dilute mineral acid solutions.

23. Although metallic lead is placed somewhat above hydrogen in the metal activity series, it is strictly not utilized practically to prepare hydrogen from dilute hydrochloric or sulphuric acid. What is the fundamental chemical reason for this?
(A) It is far too electropositive and reacts with extreme explosive violence.
(B) It rapidly forms an insoluble coating of lead salt that completely stops the reaction.
(C) It chemically catalyzes the unwanted oxidation of liberated hydrogen directly into water.
(D) It rapidly dissolves entirely in the dilute acids without producing any gas whatsoever.

Ans : (B)

Lead is theoretically capable of displacing hydrogen. However, when treated with dilute sulfuric or hydrochloric acids, it rapidly forms a completely insoluble protective layer of lead sulfate or chloride. This impermeable coating permanently halts any further chemical reaction immediately.

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24. Assertion Very dilute nitric acid successfully reacts directly with magnesium and manganese metals at extremely low temperatures to liberate pure hydrogen gas.
Reason Nitric acid is a fundamentally weak oxidizing agent that entirely lacks the chemical ability to oxidize the evolved hydrogen into water.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (C)

Magnesium and manganese uniquely liberate hydrogen from highly diluted nitric acid. However, the reason provided is entirely false because nitric acid is ordinarily a remarkably strong oxidizing agent. Its oxidizing capability is merely suppressed due to extreme aqueous dilution.

25. A student tabulated the ion formation characteristics of hydrogen, an alkali metal (Sodium), and a halogen (Chlorine).

Element	**Process**	**Ion Formed**	**Nature of Ion**
Hydrogen	$H \rightarrow H^+ + e^-$	H^+	Cation
Hydrogen	$H + e^- \rightarrow H^-$	H^-	Anion
Sodium	$Na \rightarrow Na^+ + e^-$	Na^+	Cation
Chlorine	$Cl + e^- \rightarrow Cl^-$	Cl^-	Anion

What does this data about hydrogen's ion formation demonstrate?
(A) Hydrogen is exclusively an alkali metal.
(B) Hydrogen is exclusively a halogen.
(C) Hydrogen shows a dual nature, resembling both alkali metals and halogens.
(D) Hydrogen is an inert element and does not form ions readily.

Ans : (C)

The table illustrates that hydrogen can lose an electron to form a cation (H^+), similar to the alkali metal sodium. It can also gain an electron to form an anion (H^-), similar to the halogen chlorine. This ability to form both a positive and a negative ion demonstrates its dual nature.

26. Consider the following statements regarding the specific reaction of various metals with strong concentrated alkalis

I. Zinc strongly reacts with boiling sodium hydroxide to form soluble sodium zincate.
II. Aluminium rapidly reacts with caustic potash to successfully liberate pure oxygen gas.
III. Amphoteric metals naturally react with both strong acids and alkalis to essentially evolve hydrogen.
IV. Lead smoothly reacts with hot sodium hydroxide to form a stable compound called sodium plumbite.

Which combinations of the above statements are entirely correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (B)

Amphoteric metals like zinc, aluminium, tin, and lead react robustly with strong boiling alkalis to successfully liberate hydrogen gas, not oxygen. They form complex soluble salts, such as sodium zincate and sodium plumbite, confirming their unique dual chemical behavior.

27. Match the specific amphoteric metal reacting with hot NaOH in List-I with the corresponding complex soluble salt formed in List-II.
List-I (Metal)
P. Zinc
Q. Aluminium
R. Tin
S. Lead
List-II (Salt Formed)
I. Sodium stannite
II. Sodium plumbite
III. Sodium zincate
IV. Sodium aluminate
(A) P-III, Q-IV, R-I, S-II
(B) P-III, Q-I, R-IV, S-II
(C) P-IV, Q-III, R-II, S-I
(D) P-II, Q-IV, R-III, S-I

Ans : (A)

Amphoteric metals dissolve completely in hot concentrated sodium hydroxide. Zinc produces sodium zincate, aluminium predictably yields sodium aluminate, tin smoothly generates sodium stannite, and lead chemically transforms into sodium plumbite, with all these reactions simultaneously releasing pure hydrogen gas.

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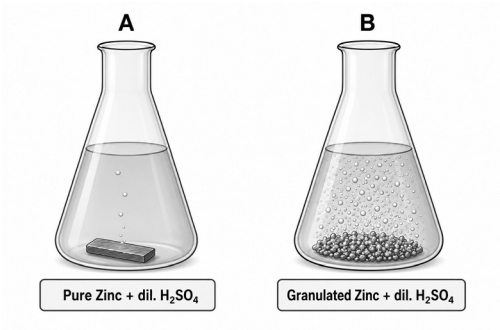
28. The diagram shows two setups for producing hydrogen. Setup B, using granulated zinc, is preferred over Setup A, using pure zinc. What is the primary reason for this preference?



(A) Granulated zinc is cheaper and more readily available than pure zinc.
(B) Granulated zinc contains impurities like copper that act as a catalyst.
(C) Granulated zinc has a larger surface area, which slows down the reaction.
(D) Pure zinc reacts too violently and makes the reaction difficult to control.

Ans : (B)

The reaction with pure zinc is extremely slow. Granulated zinc contains small amounts of copper as an impurity. These impurities, in contact with zinc in the acid, form minute electrochemical cells. This has a catalytic effect, significantly increasing the rate of reaction and leading to a much faster, steadier production of hydrogen gas.

29. In the standard laboratory preparation of hydrogen gas using dilute acids, why are commercial zinc granules heavily preferred over highly pure zinc blocks?
(A) Granulated zinc is considerably cheaper to manufacture than highly pure zinc blocks.
(B) Granulated zinc contains trace copper impurities which successfully catalyze and visibly speed up the chemical reaction.
(C) Pure zinc always reacts too violently and frequently causes dangerous laboratory explosions.
(D) Pure zinc instantly forms an insoluble salt coating that permanently stops the desired chemical reaction.

Ans : (B)

Granulated zinc naturally contains minor copper impurities. These trace metallic inclusions effectively act as a chemical catalyst, establishing microscopic local galvanic cells. This catalytic effect significantly increases the overall reaction rate with dilute acids compared to using highly pure zinc.

30. Hydrogen gas generated in the laboratory is collected exclusively by the downward displacement of water. What specific physical properties dictate this exact collection method?
(A) It is exceptionally highly soluble in water and significantly lighter than atmospheric air.
(B) It is virtually entirely insoluble in water and considerably heavier than atmospheric air.
(C) It is virtually insoluble in water and severely forms a highly explosive gaseous mixture with air.
(D) It is easily and rapidly liquefied completely under standard moderate hydrostatic water pressure.

Ans : (C)

Hydrogen dissolves poorly in water, allowing efficient collection over this liquid. It strictly cannot be collected by downward displacement of atmospheric air because it effortlessly mixes with oxygen to generate an extremely dangerous and violently explosive gaseous chemical mixture.

31. Which of the following is strictly NOT a mandatory safety precaution required during the standard laboratory preparation of hydrogen using zinc granules and dilute acid?
(A) The entire apparatus must be completely airtight with absolutely no gas leakage allowed.
(B) The thistle funnel stem must remain strictly above the liquid acid level inside the flask.
(C) Absolutely no naked flame should ever be kept burning near the actively working experimental setup.
(D) The gas should exclusively be collected only after entirely expelling all initial air from the flask.

Ans : (B)

The lower tip of the thistle funnel must remain completely submerged beneath the liquid acid level. If the stem is carelessly left above the surface, the freshly generated hydrogen gas will dangerously escape outwards directly through the funnel tube.

32. In the highly important first step of the industrial Bosch process, superheated steam is forcefully pushed over red-hot coke at approximately 1000°C. What is the official name and exact

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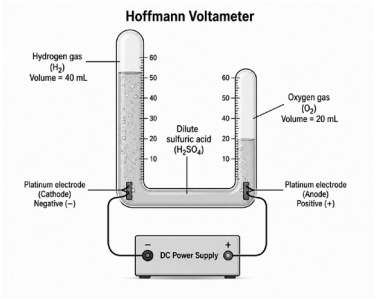
combination successfully synthesizes unique ionic chemical compounds precisely classified as metallic hydrides, such as sodium hydride and calcium hydride, respectively.

50. The apparatus shown is used for the electrolysis of acidulated water. Gas is collected above the cathode and anode. Which option correctly identifies the gas at each electrode and the volume ratio?



(A) Cathode: Oxygen, Anode: Hydrogen; Ratio 1:2
(B) Cathode: Hydrogen, Anode: Oxygen; Ratio 2:1
(C) Cathode: Hydrogen, Anode: Oxygen; Ratio 1:1
(D) Cathode: Oxygen, Anode: Hydrogen; Ratio 2:1

Ans : (B)

During the electrolysis of acidulated water, positively charged hydrogen ions (H^+) are attracted to the negative electrode (cathode), where they gain electrons and form hydrogen gas (H^+). Negatively charged hydroxide ions (OH^-) move to the positive electrode (anode) to form oxygen gas (O_2). The overall reaction $2H_2O \rightarrow 2H_2 + O_2$ produces hydrogen and oxygen in a 2:1 volume ratio.

51. What exactly happens chemically when the solid metallic hydrides successfully formed by the direct reaction of hydrogen and active alkaline metals are subsequently treated strictly with cold water?

(A) They simply dissolve smoothly to strongly form acidic solutions and safely release pure oxygen.
(B) They quietly decompose to entirely reform the original metal and liquid water.
(C) They aggressively rapidly react to strongly form metal hydroxides and fiercely release hydrogen gas.
(D) They absolutely do not react heavily with water as they are chemically highly stable.

Ans : (C)

Ionic metallic hydrides, exactly like calcium hydride or sodium hydride, are intensely reactive chemical compounds. When they physically contact standard water, they decompose violently, successfully generating strongly alkaline metal hydroxide solutions while simultaneously releasing massive amounts of pure hydrogen gas.

52. When pure hydrogen gas is continuously gently passed directly over strongly heated solid black copper (II) oxide, a distinct visible color change is observed. What is the precise final color of the solid product, and what exact substance does it represent?

(A) Yellow, clearly representing cuprous oxide
(B) Grey, clearly representing zinc metal
(C) Reddish-brown, clearly representing pure copper metal
(D) White, clearly representing copper hydroxide

Ans : (C)

Hydrogen acts as a potent reducing agent at elevated temperatures. When it successfully reacts with heavily heated black copper oxide, it powerfully strips away the oxygen. This vital chemical reduction effectively yields pure metallic copper, visibly leaving a reddish-brown residue.

53. In the broad classical chemical definition, oxidation can involve several distinct specific types of atomic transfers. Which of the following precisely correctly represents a classical oxidation chemical process?

(A) The absolute removal of strongly electronegative oxygen entirely from a compound
(B) The direct successful addition of an entirely strongly electropositive element
(C) The absolute removal of strongly electropositive hydrogen entirely from a compound
(D) The direct successful gain of loose electrons completely by a neutral atom

Ans : (C)

In classical chemical terminology, oxidation extends beyond merely adding oxygen. It fundamentally includes the direct addition of any electronegative element, as well as the deliberate chemical removal of hydrogen or any strongly electropositive atomic species from a given molecular compound.

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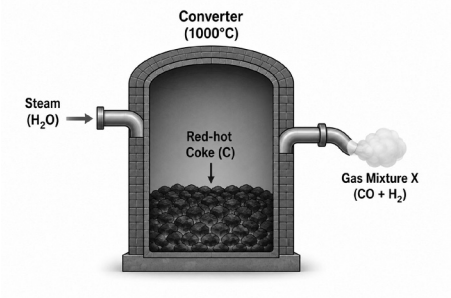
(B) It chemically reacts directly with hydrogen gas to readily produce water and sulphur dioxide.
(C) It rapidly strongly catalyzes the completely spontaneous combustion of purified hydrogen gas.
(D) It physically selectively dissolves pure hydrogen gas completely, severely leaving exactly zero yield.

Ans : (B)

Concentrated sulfuric acid is a remarkably powerful oxidizing agent. If utilized for drying, it chemically reacts directly with the reducing hydrogen gas, yielding water and unwanted sulfur dioxide, effectively defeating the primary purpose of obtaining pure, dry hydrogen.

37. The diagram shows the first stage of the Bosch process for the industrial manufacture of hydrogen. Steam is passed over red-hot coke at 1000°C. What is the name of the gaseous mixture 'X' produced?



(A) Producer gas
(B) Water gas
(C) Coal gas
(D) Natural gas

Ans : (B)

In the first step of the Bosch process, steam is passed over incandescent coke (carbon) at a high temperature of about 1000°C. This endothermic reaction produces an equimolar mixture of carbon monoxide (CO) and hydrogen (H_2). This specific industrial gas mixture, (CO + H_2), is known as water gas.

38. After the secondary catalytic chemical reaction occurs in the Bosch process, large amounts of carbon dioxide must be completely removed from the newly formed hydrogen gas. How is this industrial separation primarily physically achieved?
(A) By dissolving the gaseous mixture deeply in strongly heated water under very low pressure
(B) By forcing the mixture forcefully through extremely cold water under high pressure of 30 atm
(C) By passing the entire mixture deeply through concentrated sulphuric acid inside a scrubbing tower
(D) By condensing the carbon dioxide entirely at ultra-low sub-zero temperatures inside a condenser

Ans : (B)

To isolate pure hydrogen industrially, the resultant gaseous mixture is forcefully driven through chilled water at a high pressure of thirty atmospheres. This specific physical condition causes the highly soluble carbon dioxide to completely dissolve, leaving the insoluble hydrogen behind.

39. Assertion A small exact amount of dilute sulphuric acid is always added to pure distilled water before attempting industrial electrolysis.
Reason Pure distilled water is an extremely poor conductor of electricity, and the dilute acid effectively provides the necessarily required mobile ions to successfully facilitate electrical current flow.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Pure distilled water intrinsically contains negligible concentrations of dissolved mobile ions, rendering it an extremely poor electrical conductor. The deliberate addition of trace amounts of sulfuric acid massively increases its electrical conductivity, actively facilitating the efficient electrolytic decomposition process.

40. Following the primary removal of carbon dioxide in the Bosch process, how is the residual unreacted carbon monoxide ultimately entirely eliminated from the final hydrogen gas product?
(A) By passing the entire gas firmly through an ammoniacal cupric chloride chemical solution
(B) By passing the remaining gas vigorously through a strong concentrated caustic potash solution
(C) By carefully burning the gaseous mixture in a highly limited strictly controlled supply of oxygen

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thus creating a visibly milky and completely turbid appearance in the solution.

15. A segment of the activity series is provided, detailing the reaction of metals with dilute acids.

Metal	**Reaction with dilute HCl/ H_2SO_4**
K, Na	React with explosive violence.
Mg, Al, Zn, Fe	React less vigorously.
Pb, [H]	React slowly or not at all (for Pb).
Cu, Hg, Ag	Y

Based on the trend shown, what is the correct description for 'Y'?

(A) React vigorously to produce hydrogen.
(B) React only with concentrated acids.
(C) Do not displace hydrogen from dilute acids.
(D) React slowly to form an insoluble salt layer.

Ans : (C)

Metals positioned below hydrogen ([H]) in the activity series, such as Copper (Cu), Mercury (Hg), and Silver (Ag), are less reactive than hydrogen. Consequently, they are unable to displace hydrogen from dilute mineral acids like HCl or H_2SO_4. The reaction does not occur under these conditions.

16. The chemical reaction between red-hot iron metal and steam is a fundamentally reversible process. What specific condition must be maintained to ensure the reaction proceeds entirely in the forward direction to continuously produce iron oxide and hydrogen?

(A) The steam must be continuously condensed into liquid water.
(B) The newly formed hydrogen gas must be continuously removed from the vessel.
(C) The iron must be alloyed heavily with liquid mercury.
(D) The chemical reaction must be carried out in a tightly closed vessel.

Ans : (B)

The chemical interaction between red-hot iron and steam forms triferric tetroxide and hydrogen reversibly. To strictly maintain the forward reaction and entirely prevent the freshly generated hydrogen from reducing the metallic oxide back to iron, the gas must be continuously removed.

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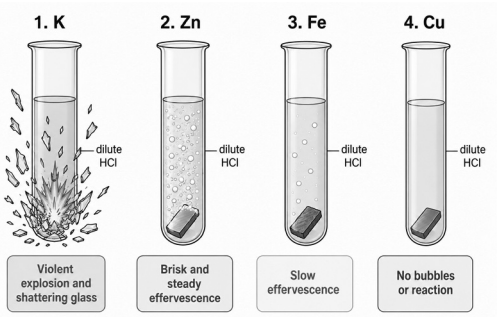
17. Magnesium interacts very slowly with boiling water but reacts vigorously when heated in steam. What are the respective magnesium-based chemical products formed in these two distinct reactions?

(A) Magnesium oxide in both cases
(B) Magnesium hydroxide in both cases
(C) Magnesium hydroxide with boiling water, and magnesium oxide with steam
(D) Magnesium oxide with boiling water, and magnesium hydroxide with steam

Ans : (C)

When magnesium reacts slowly with boiling water, it produces magnesium hydroxide and hydrogen gas. Conversely, when exposed to high-temperature steam, the metal burns with an intense white light, generating white magnesium oxide ash alongside the rapid liberation of hydrogen gas.

18. The diagram shows the reaction of four different metals with dilute acid. Based on the observed vigour of the reaction, what is the correct decreasing order of reactivity for these metals?



(A) K > Fe > Zn > Cu
(B) Cu > Fe > Zn > K
(C) K > Zn > Fe > Cu
(D) Zn > K > Fe > Cu

Ans : (C)

The reactivity of a metal with dilute acid is indicated by the rate of hydrogen evolution. Potassium (K) reacts explosively, placing it highest. Zinc (Zn) shows brisk effervescence, indicating it is more reactive than Iron (Fe), which reacts slowly. Copper (Cu), being below hydrogen in the activity series, does not react at all.

19. When superheated steam is continuously passed over strongly heated zinc metal, hydrogen gas is liberated alongside the formation of solid zinc oxide. What is the characteristic thermochromic

45. The table summarises key chemical reactions of hydrogen with various non-metals.

Reaction with	Equation	Condition
Oxygen (O_2)	$2H_2 + O_2 \rightarrow 2H_2O$	Electric spark
Chlorine (Cl_2)	$H_2 + Cl_2 \rightarrow 2HCl$	Diffused sunlight
Nitrogen (N_2)	$N_2 + 3H_2 \rightarrow 2NH_3$	X

Identify the correct set of conditions 'X' required for the synthesis of ammonia, also known as the Haber process.

(A) Temperature 1000°C, atmospheric pressure
(B) Temperature 450-500°C, pressure 200-900 atm, Fe catalyst
(C) Low temperature, high pressure, no catalyst
(D) High temperature, low pressure, Ni catalyst

Ans : (B)

The synthesis of ammonia from nitrogen and hydrogen (Haber process) is a reversible reaction that requires specific optimal conditions to achieve a reasonable yield. These conditions are a temperature range of 450-500°C, very high pressure (200-900 atm), and the use of finely divided iron as a catalyst.

46. The exact chemical reaction rate between equal mixed volumes of pure hydrogen and pure chlorine is highly dependent on ambient light conditions. Under which specific precise condition does the reaction safely become violently explosive?

(A) In total absolute darkness
(B) In normal diffused sunlight
(C) In bright direct intense sunlight
(D) Under controlled artificial red light

Ans : (C)

Hydrogen and chlorine vigorously interact to produce hydrogen chloride gas. While they combine quite slowly and safely in diffused ambient daylight, exposing the exact same gaseous mixture to direct, intense sunlight dramatically accelerates the photochemical process, triggering a massive explosion.

47. Consider the following precise statements regarding the industrial synthesis of ammonia gas strictly using the Haber Process

I. The precise combining reactants are exactly three volumes of pure nitrogen and strictly one volume of pure hydrogen.
II. The industrial reaction securely operates at a severely high pressure of 200-900 atm.
III. Finely divided iron is heavily used exclusively as a chemical catalyst.
IV. Molybdenum is precisely used exclusively as a chemical promoter.

Which exact combination of the above statements is entirely accurate?

(A) I, II, and III
(B) II, III, and IV
(C) I, III, and IV
(D) I, II, III, and IV

Ans : (B)

The renowned Haber process successfully synthesizes ammonia using extreme pressures, finely divided iron as the primary catalyst, and molybdenum acting as a promoter. However, the exact stoichiometric ratio strictly requires three volumes of hydrogen combining with one volume of nitrogen.

48. What explicitly occurs chemically when pure dry hydrogen gas is systematically bubbled directly through a sealed container holding strongly heated molten sulphur?

(A) It quickly forms solid bright yellow crystals of sulphur hydride.
(B) It actively chemically reacts to directly produce gaseous hydrogen sulphide.
(C) It vigorously rapidly reduces the molten sulphur directly to liquid water.
(D) No chemical reaction whatsoever occurs as non-metals strictly do not react with hydrogen.

Ans : (B)

When pure hydrogen gas is deliberately passed entirely through heavily heated, molten sulfur, a direct chemical combination rapidly occurs. This specific high-temperature interaction successfully yields hydrogen sulfide, an extremely foul-smelling, distinctly toxic chemical gas with the molecular formula H_2S.

49. When exceptionally dry pure hydrogen gas is actively passed directly over strongly heated, highly electropositive solid metals like pure potassium, pure sodium, or pure calcium, what is the exact resulting general product type?

(A) Stable metallic hydroxides
(B) Stable metallic hydrides
(C) Stable metallic oxides
(D) Stable metallic carbonates

Ans : (B)

Highly reactive electro-positive alkali and alkaline earth metals directly absorb dry hydrogen gas at significantly elevated temperatures. This specific

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molecular composition of the valuable gaseous mixture produced?
(A) Producer gas ($CO + N_2$)
(B) Water gas ($CO + H_2$)
(C) Natural gas ($CH_4 + C_2H_6$)
(D) Synthesis gas ($CO_2 + H_2$)

Ans : (B)

During the initial highly endothermic stage of the Bosch process, superheated steam physically interacts with incandescent carbon at one thousand degrees Celsius. This specific industrial chemical procedure successfully generates water gas, an equimolar gaseous mixture comprising carbon monoxide and hydrogen.

33. For the laboratory preparation of hydrogen, a student considers several combinations of reactants.

Combination	**Reactants**	**Expected Problem**
1	Na + dil. HCl	Reaction is too violent and explosive.
2	Pb + dil. H_2SO_4	Insoluble $PbSO_4$ coating stops the reaction.
3	Cu + dil. HCl	No reaction occurs.
4	Granulated Zn + dil. H_2SO_4	X

Which statement best describes the outcome 'X' for combination 4, making it the preferred method?
(A) The reaction is too slow to be practical.
(B) The reaction is dangerously explosive.
(C) The reaction is exothermic but controllable.
(D) The reaction produces toxic gas impurities.

Ans : (C)

Zinc is ideally placed in the activity series to react with dilute acids at a moderate and controllable rate. The reaction is effervescent and exothermic but not violent like with Sodium. The issues with lead (insoluble salt formation) and copper (unreactive) make them unsuitable, establishing granulated zinc as the preferred reactant.

34. Impurities are frequently present in the crude hydrogen gas generated chemically in the laboratory. Which of the following statements concerning the effective removal of these specific impurities are completely correct?
I. Silver nitrate solution successfully removes highly toxic arsine and phosphine gases.
II. Lead nitrate solution is strictly utilized to remove sulphur dioxide gas entirely.
III. Caustic potash solution successfully pulls out carbon dioxide, sulphur dioxide, and oxides of nitrogen.
IV. Anhydrous calcium chloride is highly effective and frequently used to directly dry the hydrogen gas.
(A) I, II, and IV
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and III

Ans : (B)

During laboratory purification, a silver nitrate solution eliminates arsine and phosphine. Caustic potash successfully absorbs carbon dioxide, sulfur dioxide, and nitrogen oxides. Lead nitrate is specifically utilized to precipitate hydrogen sulfide, not sulfur dioxide. Finally, desiccants remove moisture.

35. During the critical second step of the industrial Bosch process, water gas is heavily mixed with excess superheated steam and passed over a heated chemical catalyst and a promoter. Identify the entirely correct operational catalyst and promoter combination utilized.
(A) Catalyst Iron (III) oxide; Promoter Chromium (III) oxide
(B) Catalyst Chromium (III) oxide; Promoter Iron (III) oxide
(C) Catalyst Finely divided iron; Promoter Molybdenum
(D) Catalyst Nickel; Promoter Copper

Ans : (A)

In the subsequent exothermic conversion phase of the Bosch process, excess steam reacts with water gas. This vital chemical transformation utilizes ferric oxide serving as the primary catalyst, while chromic oxide acts distinctly as a chemical promoter to enhance efficiency.

36. Although concentrated sulphuric acid is widely recognized as a remarkably powerful drying agent, it is never used to practically dry hydrogen gas. What is the precise chemical reason for this specific restriction?
(A) It permanently physically absorbs hydrogen to slowly form complex aqueous sulfurous acids.

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54. What is the precise fundamental nature of the important chemical reaction occurring when pure hydrogen gas is actively added securely to unsaturated organic compounds like ethylene to successfully form ethane?
(A) Dehydrogenation reaction
(B) Hydrogenation reaction
(C) Substitution reaction
(D) Condensation reaction

Ans : (B)

The precise chemical process where molecular hydrogen is systematically added directly across the double or triple bonds of unsaturated organic compounds is termed hydrogenation. This vital industrial reaction successfully transforms unsaturated molecules, like ethylene, entirely into saturated hydrocarbons, like ethane.

55. Hydrogen gas acts as a reducing agent when passed over heated metallic oxides. The observed colour changes are recorded below.

Metallic Oxide	**Formula**	**Initial Colour**	**Final Colour of Metal**
Lead(II) oxide	PbO	Yellow	Silvery grey
Copper(II) oxide	CuO	Black	X
Iron(III) oxide	Fe_2O_3	Brown	Grey

What is the colour 'X' of the final product when hydrogen reduces black copper(II) oxide?
(A) Silvery white
(B) Yellowish green
(C) Reddish brown
(D) Bluish white

Ans : (C)

When hydrogen gas is passed over heated black copper(II) oxide, it reduces the oxide to copper metal and forms water. The reaction is: $CuO + H_2 \rightarrow Cu + H_2O$. Copper metal has a characteristic reddish-brown colour. Therefore, the black solid turns reddish-brown as the reaction proceeds.

56. Which of the following precisely stated procedures is strictly NOT a recognized valid industrial or practical chemical application of pure hydrogen gas?
(A) Large-scale manufacturing of pure ammonia via the established Haber process
(B) Systematic industrial hydrogenation of liquid vegetable oils to effectively form solid fats
(C) Serving directly as an active potent oxidizing agent in heavy metallurgical extraction processes
(D) Creating severely high temperatures directly in specialized oxyhydrogen cutting welding torches

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Ans : (C)

Hydrogen gas is utilized extensively for synthesizing ammonia, hardening vegetable oils, and fueling high-temperature welding torches. However, in metallurgical extraction procedures, hydrogen acts fundamentally as a powerful reducing agent to efficiently isolate metals from their oxides, never as an oxidizer.

57. According strictly to the modern fundamental electronic concept of chemistry, how is the specific chemical process of oxidation precisely mathematically defined?
(A) A process in which an atom or ion strictly actively gains valence electrons
(B) A process in which an atom or ion strictly actively loses valence electrons
(C) A process involving the direct addition of any strongly electropositive ion
(D) A process involving the direct removal of any strongly electronegative ion

Ans : (B)

The modern electronic theory firmly defines chemical oxidation strictly as the absolute loss of electrons by an atom, molecule, or ion. Conversely, the exact opposite chemical mechanism, successfully involving the direct gain of electrons, is explicitly defined as chemical reduction.

58. An oxidising agent is defined chemically as a distinct substance that strictly oxidises other reacting substances. What exactly happens fundamentally to the primary oxidising agent itself during a typical complete redox chemical reaction?
(A) It strictly actively provides loosely held valence electrons tightly to the other substance.
(B) It completely naturally gets chemically oxidized entirely simultaneously.
(C) It firmly gets naturally chemically reduced by actively accepting electrons or providing oxygen.
(D) It firmly rigidly remains completely entirely structurally and chemically unchanged.

Ans : (C)

During any simultaneous redox reaction, an oxidizing agent forces another chemical species to undergo oxidation. In doing so, the oxidizing agent fundamentally acts by either donating its oxygen or actively accepting transferred electrons, thereby undergoing chemical reduction itself in the process.

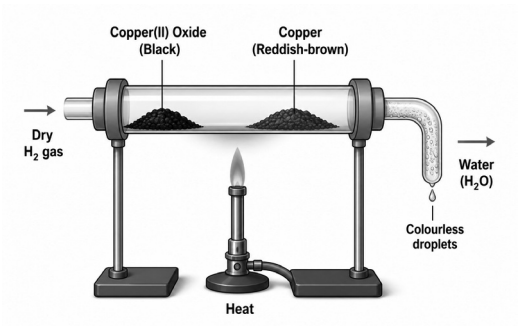
59. Which of the following precisely stated distinct chemical processes does strictly NOT functionally fit the accepted classical definition of chemical reduction?

(A) The direct complete addition of elemental hydrogen firmly to a compound
(B) The absolute successful removal of bound oxygen cleanly from a metallic oxide
(C) The direct successful addition of a strongly electropositive ion tightly to a substance
(D) The direct complete addition of a highly electronegative ion tightly to a metal

Ans : (D)

Classical reduction is strictly defined by the direct addition of hydrogen or electropositive elements, and the removal of oxygen or electronegative elements. Adding an electronegative ion directly to a metal represents classical oxidation, completely contradicting the fundamental principles of reduction.

60. The diagram illustrates the reaction of dry hydrogen gas passing over a heated metallic oxide. A black solid turns reddish-brown, and a colourless liquid is formed. What role does hydrogen play in this transformation?



(A) An oxidising agent
(B) A reducing agent
(C) A catalyst
(D) A dehydrating agent

Ans : (B)

In this reaction, hydrogen removes oxygen from the copper(II) oxide (CuO) to form water (H_2O). A substance that removes oxygen from another substance is defined as a reducing agent. Consequently, the black copper(II) oxide is reduced to reddish-brown copper metal, while the hydrogen itself is oxidised to water.

61. Consider the highly specific chemical redox reaction thoroughly represented by the following equation $CuO + H_2Cu + H_2OWhich$ chemical substance acts strictly as the primary reducing agent, and which exact substance logically gets chemically reduced?

(A) Reducing agent CuO; Reduced substance H_2
(B) Reducing agent H_2; Reduced substance CuO
(C) Reducing agent H_2; Reduced substance Cu
(D) Reducing agent CuO; Reduced substance H_2O

Ans : (B)

In this specific redox equation, molecular hydrogen actively removes bound oxygen from the copper oxide, thereby functioning directly as the primary reducing agent. Consequently, the copper (II) oxide inevitably loses its oxygen content and becomes successfully chemically reduced to metallic copper.

62. In the classical chemical redox reaction completely occurring directly between pure hydrogen sulphide and pure chlorine gases $H_2S + Cl_2 \rightarrow 2HCl + S$
Which distinct chemical species undeniably behaves exactly as the oxidizing agent?

(A) Hydrogen sulphide, primarily because it chemically essentially provides the hydrogen
(B) Chlorine, primarily because it actively strongly pulls out hydrogen from hydrogen sulphide
(C) Sulphur, primarily because it rapidly naturally forcefully loses its hydrogen
(D) Hydrogen chloride, primarily because it smoothly thoroughly gains an electronegative ion

Ans : (B)

Chlorine systematically removes bound hydrogen directly from the hydrogen sulfide molecule. By actively eliminating this electropositive component from another substance, elemental chlorine distinctly acts as the powerful oxidizing agent, whilst simultaneously becoming chemically reduced to form stable hydrogen chloride gas.

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63. In the laboratory preparation of hydrogen, the gas produced contains several impurities which must be removed.

Purifying Solution	**Formula**	**Impurity Removed**
Silver nitrate	$AgNO_3$	Arsine (AsH_3) and Phosphine (PH_3)
Lead (II) nitrate	$Pb(NO_3)_2$	X
Potassium hydroxide	KOH	CO_2, SO_2, oxides of nitrogen
Anhydrous calcium chloride	$CaCl_2$	Water vapour (H_2O)

Identify the impurity 'X' that is specifically removed by passing the gas through lead (II) nitrate solution.

(A) Hydrogen sulphide (H_2S)
(B) Carbon monoxide (CO)
(C) Ammonia (NH_3)
(D) Hydrogen chloride (HCl)

Ans : (A)

Lead (II) nitrate solution is used to remove hydrogen sulphide impurity. H_2S reacts with $Pb(NO_3)_2$ to form a black precipitate of lead (II) sulphide (PbS), effectively removing the gaseous impurity from the hydrogen stream. The other solutions are used for removing different specific impurities as listed in the table.

64. How can a skilled laboratory chemist easily physically confirm if a specific completely unknown solid chemical substance is fundamentally a strong powerful oxidizing agent?

(A) By heating it strongly, which may liberate oxygen gas that kindles a glowing splinter
(B) By warming it directly with nitric acid to instantly produce dense white fumes
(C) By carefully observing if it completely safely decolorizes a completely colourless solution
(D) By diligently checking if it chemically reacts vigorously with extremely pure cold water

Ans : (A)

A definitive experimental laboratory test for powerful solid oxidizing agents involves heavily heating the chemical sample. If it genuinely possesses strong oxidizing characteristics, it frequently decomposes to liberate pure oxygen gas, rapidly reigniting a dimly glowing wooden test splinter instantly.

65. What is a highly characteristic distinct visual laboratory chemical test for successfully reliably confirming the definite presence of a strong liquid reducing agent?

(A) It rapidly irreversibly naturally turns entirely clear liquid lime water entirely milky.
(B) It completely thoroughly decolorizes the distinct dark pink colour of a potassium permanganate solution.
(C) It effectively readily heavily liberates pale yellowish-green pure chlorine gas on gentle warming.
(D) It actively thoroughly naturally strictly turns entirely standard red litmus paper strongly blue.

Ans : (B)

Strong chemical reducing agents effectively transfer electrons to potent oxidizers. When introduced directly into a distinctly dark pink aqueous solution of potassium permanganate, the reducing agent actively reduces the highly oxidized manganese ions, completely bleaching and perfectly decolorizing the vivid solution.

66. In the clearly strictly balanced ionic chemical redox displacement reaction equation $Cu^{2+} + Zn \rightarrow Zn^{2+} + Cu$
Which specific thoroughly isolated ionic half-reaction entirely correctly mathematically represents the exact oxidation process occurring?

(A) $Cu^{2+} + 2e^- \rightarrow Cu$
(B) $Zn^{2+} + 2e^- \rightarrow Zn$
(C) $Zn \rightarrow Zn^{2+} + 2e^-$
(D) $Cu \rightarrow Cu^{2+} + 2e^-$

Ans : (C)

According to rigorous electronic theory, chemical oxidation is definitively characterized by the absolute loss of valence electrons. In this specific displacement reaction, the neutral metallic zinc atom actively loses two distinct electrons to form a positive zinc ion, directly undergoing oxidation.

67. Hydrogen is placed in Group 1 of the Periodic Table mainly because it:

(A) Has one neutron
(B) Has one valence electron
(C) Is a gas
(D) Forms water

Ans : (B)

Explanation: Hydrogen has atomic number 1 and electronic configuration 1. Like alkali metals, it possesses one electron in its outermost shell. Because of this similarity, hydrogen is

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95. Complete and balance the following equations:

(i) $Mg + H_2O \longrightarrow$

(ii) $Zn + HCl \longrightarrow$

(iii) $Fe + HCl \longrightarrow$

(iv) $K + H_2O \longrightarrow$

(v) $Fe + H_2O \longrightarrow$

Ans :

(i) $Mg + H_2O \longrightarrow MgO + H_2$

(ii) $Zn + 2HCl \longrightarrow ZnC1_2 + H_2$

(iii) $Fe + 2HC1 \longrightarrow FeC1_2 + H_2$

(iv) $2K + 2H_2O \longrightarrow 2KOH + H_2$

(v) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$.

DIRECTION : Give reason why ?

96. Give reasons why

(i) Hydrogen was previously used in meteorological balloons.

(ii) Hydrogen is no longer used in meteorological balloons.

(iii) Hydrogen is not collected in air.

(iv) Hydrogen is used as a fuel.

(v) Hydrogen obtained by the reaction of zinc and dilute sulphuric acid has a peculiar (fishy) smell.

(vi) Hydrogen obtained by Bosch process is passed through ammoniacal cuprous chloride.

(vii) Hydrogen manufactured by Bosch process is passed through water under pressure.

(viii) Hydrogen is not prepared by the reaction of aluminium with dilute acids.

(ix) In laboratory, hydrogen is not prepared by the reaction of lead with dilute sulphuric acid or dilute hydrochloric acid.

(x) The apparatus used for the preparation of hydrogen must be airtight.

Ans :

(i) Hydrogen was previously used in meteorological balloons because of its lowest density and high lifting power.

(ii) Hydrogen is now no longer used in meteorological balloons as it is highly inflammable in nature, i.e. it catches fire very easily.

(iii) Hydrogen is not collected in air because it forms explosive mixture with air.

(iv) Hydrogen is used as a fuel because on burning it produces large amount of heat energy, i.e. it has high calorific value.

(v) Hydrogen has peculiar smell because it contains the impurities of arsine and phosphine.

(vi) Hydrogen obtained by Bosch process is passed through ammoniacal cuprous chloride solution so as to absorb carbon monoxide.

(vii) Hydrogen obtained by Bosch process is passed through water under pressure to remove carbon dioxide.

(viii) Aluminium is not used for preparation of hydrogen from acids because a thin but a tough layer of oxide is formed which prevents the further reaction of acid with metal.

(ix) In laboratory hydrogen is not prepared by the reaction of lead with dilute sulphuric acid or dilute hydrochloric acid because it forms insoluble lead sulphate and insoluble lead chloride respectively which prevents the reaction of metals with acids.

(x) The apparatus used for the preparation of hydrogen must be airtight because any leakage can cause explosion as hydrogen is highly inflammable.

97. Give reasons why

(i) during the laboratory preparation of hydrogen no flame should be kept near the apparatus.

(ii) hydrogen is not collected in air but is collected over water.

(iii) hydrogen obtained from granulated zinc has a peculiar smell.

(iv) colour of ferric chloride changes when it comes in contact with zinc and dilute hydrochloric acid.

(v) lead is not used for the preparation of hydrogen from dilute hydrochloric acid or dilute sulphuric acid.

Ans :

(i) It is so because hydrogen is highly inflammable, i.e. it catches fire very easily.

(ii) It is not collected in air as it forms explosive mixture in air. It is collected over water as it is insoluble in water.

(iii) As it contains the impurities of arsine and phosphine.

(iv) Zinc and dil. HCl produces nascent hydrogen, which reduces ferric chloride to ferrous chloride.

(v) On reaction, lead chloride and lead sulphate are formed which are insoluble in water.

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75. The catalyst used in the Haber Process is:
(A) Nickel
(B) Platinum
(C) Iron
(D) Copper

Ans : (C)

Explanation: In the Haber Process, hydrogen combines with nitrogen to form ammonia. Finely divided iron is used as the catalyst, while molybdenum acts as a promoter. The catalyst increases the rate of reaction without being consumed during the process.

76. Which of the following is a use of hydrogen?
(A) Manufacture of glass only
(B) Hydrogenation of oils
(C) Manufacture of cement only
(D) Water purification only

Ans : (B)

Explanation: Hydrogen is widely used for hydrogenation of vegetable oils to produce vanaspati ghee. In the presence of a nickel catalyst, hydrogen adds to unsaturated compounds and converts them into saturated compounds. Besides this, hydrogen is also used as a fuel, reducing agent in metallurgy and for welding operations.

ONE MARK QUESTIONS

77. What is the purpose of oxyhydrogen flame ?

Ans :

It is used for welding and cutting of metals.

78. Who discovered hydrogen?

Ans :

The discovery of hydrogen goes to Henry cavendish.

79. What do you observe when hydrogen comes in contact with blue litmus.

Ans :

No change.

80. Name the metal which reacts reversibly with steam.

Ans :

Iron (Fe)

81. What is the atomicity of hydrogen?

Ans :

2

82. In free state, where hydrogen occurs? Why does it rarely occur in free state?

Ans :

In free state, hydrogen in found on the surface of Sun and stars. It occurs rarely because it is highly reactive.

83. Name the metal which reacts reversibly with steam and write balanced chemical equation.

Ans :

Iron, $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$.

84. Define Activity Series. Name the metal which lies on the top of reactivity series.

Ans :

The series in which metals are arranged in decreasing order of reactivity is called Activity series. Potassium (K) lies on the top of reactivity series.

85. What is the valency of hydrogen.

Ans :

1

86. What is the position of hydrogen in periodic table?

Ans :

Period – 1, Group – 1.

DIRECTION : Fill in the blanks

87. Fill in the blanks:
(a) To the iron (iii) chloride solution which is (i) _____ in colour (ii) _____ is added with dilute hydrochloric acid to produce (iii) _____ hydrogen. The colour of the solution changes from (iv) _____ to (v) _____ and it undergoes the process of (vi) _____.
(b) When hydrogen is passed over heated (i) _____ which is black in colour it forms (ii) _____ copper metal. Hydrogen in this reaction is acting as (iii) _____ agent.
(c) Hydrogen is prepared in laboratory by the reaction of (i) _____ with dilute sulphuric acid. The hydrogen obtained is not pure. It

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placed in Group 1 of the Periodic Table. It can lose this electron to form H^+ ion, resembling the behaviour of alkali metals.

68. Which isotope of hydrogen contains two neutrons?
(A) Protium
(B) Deuterium
(C) Tritium
(D) Hydride

Ans : (C)

Explanation: Hydrogen exists in three isotopic forms. Protium contains no neutron, Deuterium contains one neutron and Tritium contains two neutrons. All three isotopes have the same atomic number (1) but different mass numbers because of the difference in neutron count. Tritium is represented as ${}^{3}_{1}H$.

69. Why is aluminium generally not used for laboratory preparation of hydrogen?
(A) It is expensive
(B) It is less reactive than copper
(C) It is coated with a protective oxide layer
(D) It reacts explosively

Ans : (C)

Explanation: Aluminium is covered with a thin but tough layer of aluminium oxide. This oxide layer prevents the metal from coming into direct contact with dilute acids or water. As a result, hydrogen is not liberated easily, making aluminium unsuitable for the laboratory preparation of hydrogen gas.

70. Which impurity is removed by passing impure hydrogen through lead nitrate solution?
(A) Carbon dioxide
(B) Hydrogen sulphide
(C) Moisture
(D) Nitrogen dioxide

Ans : (B)

Explanation: During purification, hydrogen is passed through lead nitrate solution to remove hydrogen sulphide (H_2S). Lead nitrate reacts with hydrogen sulphide and removes it from the gas mixture. Other impurities are removed by different reagents such as potassium hydroxide and silver nitrate solution.

71. In the electrolysis of acidulated water, hydrogen is liberated at the:
(A) Anode
(B) Cathode
(C) Electrolyte
(D) Salt bridge

Ans : (B)

Explanation: During electrolysis of acidulated water, hydrogen ions gain electrons at the cathode and form hydrogen gas. Oxygen is simultaneously liberated at the anode. This method is one of the important industrial processes used for manufacturing hydrogen.

72. Hydrogen is collected only after allowing air to escape because:
(A) Air dissolves hydrogen
(B) Air reacts with water
(C) Hydrogen-air mixture is explosive
(D) Hydrogen is poisonous

Ans : (C)

Explanation: Hydrogen forms a highly explosive mixture with air. If the collected gas contains air and is ignited, it may explode violently. Therefore, the first portion of gas is allowed to escape before collection begins. This precaution is essential during laboratory preparation of hydrogen.

73. Which property of hydrogen is demonstrated when it converts copper oxide into copper?
(A) Acidic nature
(B) Basic nature
(C) Reducing property
(D) Oxidising property

Ans : (C)

Explanation: When hydrogen is passed over heated copper oxide, it removes oxygen from copper oxide to form copper and water. Since hydrogen causes reduction of copper oxide while itself getting oxidized to water, it acts as a reducing agent. This is one of the most important chemical properties of hydrogen.

74. Hydrogen reacts with chlorine most rapidly in:
(A) Darkness
(B) Diffused sunlight
(C) Direct sunlight
(D) Cold conditions

Ans : (C)

Explanation: Hydrogen and chlorine react slowly in diffused sunlight to form hydrogen chloride gas. However, in direct sunlight the reaction becomes extremely rapid and explosive due to the high energy available. In complete darkness, the reaction practically does not occur.

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(iii) Ethane
(iv) Pale blue
(v) nickel.

DIRECTION : Name the following

92. Name the following.
(i) Two metals which react with dilute nitric acid to liberate hydrogen.
(ii) Two metals which do not displace hydrogen from dilute acids.
(iii) A salt soluble in hot water but insoluble in cold water.
(iv) A salt insoluble in all the mineral acids.
(v) A gas which forms explosive mixture with air.
(vi) A gas having rotten egg smell.
(vii) A gas which turns lead acetate solution black.
(viii) Equivolume mixture of carbon monoxide and hydrogen.

Ans :
(i) Magnesium and manganese
(ii) Copper and silver
(iii) Lead chloride
(iv) Lead sulphate, calcium sulphate or barium sulphate
(v) Hydrogen
(vi) Hydrogen sulphide
(vii) Hydrogen sulphide
(viii) Water gas.

DIRECTION : Complete the Reactions

93. Copy, complete and balance the following equations:
(i) $K + \underset{\text{cold}}{H_2O} \longrightarrow$ (ii) $Na + \underset{\text{cold}}{H_2O} \longrightarrow$
(iii) $Mg + \underset{\text{steam}}{H_2O} \longrightarrow$ (iv) $Zn + \underset{\text{steam}}{H_2O} \longrightarrow$
(v) $Fe + \underset{\text{steam}}{H_2O} \longrightarrow$ (vi) $Na + HCL \longrightarrow$
(vii) $K + HCL \longrightarrow$ (viii) $Ca + HCL \longrightarrow$
(ix) $Mg + HCL \longrightarrow$ (x) $Mg + H_2SO_4 \longrightarrow$
(xi) $Mg + HNO_3 \longrightarrow$ (xii) $Mg + HNO_3 \longrightarrow$
(xiii) $Zn + H_2SO_4 \longrightarrow$ (xiv) $Zn + NaOH \longrightarrow$
(xv) $Zn + KOH \longrightarrow$

Ans :
(i) $2K + 2H_2O\,(cold) \longrightarrow 2KOH + H_2$
(ii) $2Na + 2H_2O\,(cold) \longrightarrow 2NaOH + H_2$
(iii) $Mg + H_2O\,(steam) \longrightarrow MgO + H_2$
(iv) $Zn + H_2O\,(steam) \longrightarrow ZnO + H_2$
(v) $\underset{\text{hot}}{3Fe} + \underset{\text{steam}}{4H_2O} \rightleftharpoons Fe_3O_4 + 4H_2$
(vi) $2Na + 2HCL \longrightarrow 2NaCl + H_2$
(vii) $2K + 2HCl \longrightarrow 2KCl + H_2$
(viii) $Ca + 2HCl \longrightarrow CaCl_2 + H_2$
(ix) $Mg + 2HCl \longrightarrow MgCl_2 + H_2$
(x) $Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$
(xi) $Mg + \underset{\text{very dil.}}{2HNO_3} \longrightarrow Mg(NO_3)_2 + H_2$
(xii) $Mn + \underset{\text{very dil.}}{2HNO_3} \longrightarrow Mg(NO_3)_2 + H_2$
(xiii) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$
(xiv) $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$
(xv) $Zn + 2KOH \longrightarrow K_2ZnO_2 + H_2$

94. Complete and balance the following equations.
(i) $Al + NaOH + H_2O \longrightarrow \_\_\_ + \_\_\_$
(ii) $N_2 + H_2 \longrightarrow \_\_\_$
(iii) $CaH_2 + H_2O \longrightarrow \_\_\_ + \_\_\_$
(iv) $Fe + H_2SO_4 \longrightarrow \_\_\_ + \_\_\_$
(v) $Fe + HCl \longrightarrow \_\_\_ + \_\_\_$
(vi) $CuO + H_2 \longrightarrow \_\_\_ + \_\_\_$
(vii) $H_2S + Cl_2 \longrightarrow \_\_\_ + \_\_\_$
(viii) $Na + H_2O \longrightarrow \_\_\_ + \_\_\_$
(ix) $Fe + H_2O \rightleftharpoons \_\_\_ + \_\_\_$
(x) $Zn + H_2O \longrightarrow \_\_\_ + \_\_\_$
(xi) $Al + H_2O \longrightarrow \_\_\_ + \_\_\_$
(xii) $Pb + NaOH \longrightarrow \_\_\_ + \_\_\_$

Ans :
(i) $2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$
(ii) $N_2 + 3H_2 \longrightarrow 2NH_3$
(iii) $CaH_2 + 2H_2O \longrightarrow Ca(OH)_2 + 2H_2$
(iv) $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$
(v) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$
(vi) $CuO + H_2 \longrightarrow Cu + H_2O$
(vii) $H_2S + Cl_2 \longrightarrow 2HCl + S$
(viii) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$
(ix) $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$
(x) $Zn + H_2O \longrightarrow ZnO + H_2$
(xi) $2Al + 3H_2O \longrightarrow Al_2O_3 + 3H_2$
(xii) $Pb + 2NaOH \longrightarrow Na_2PbO_2 + H_2$

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Ans :

1. The metal oxide has been reduced to the metal.
2. Hydrogen has acted as a reducing agent.

109. A gas jar containing hydrogen is left open for some time. Later, the gas is tested and no pop sound is heard. Suggest a reason.

Ans :

1. Hydrogen is very light and diffuses rapidly into the air.
2. Most of the hydrogen escaped from the gas jar.

110. A scientist discovers an isotope of hydrogen containing one proton and three neutrons.
Will it still be hydrogen? Give reasons.

Ans :

Yes.
The identity of an element depends on its number of protons (atomic number).
Since it has one proton, it remains hydrogen despite having a different mass number.

111. A student writes:
"Hydrogen is collected by downward displacement of water because it is highly soluble in water."
Identify and correct the error.

Ans :

Error: Hydrogen is highly soluble in water.
Correction: Hydrogen is practically insoluble in water; therefore it is collected by downward displacement of water.

112. Pure hydrogen burns in pure oxygen with a flame and it forms droplets of colourless liquid 'A'.
(i) What is the colour of the flame?
(ii) Identify 'A'

Ans :

(i) Pale blue flame.
(ii) Water.

113. Name the gas evolved and write balanced chemical equation when metallic hydroxide comes in contact with moisture.

Ans :

Hydrogen. $MH + H_2O \longrightarrow MOH + H_2$
(M stands for metal)

114. What are the isotopes of hydrogen? Write their symbols, atomic numbers and mass numbers. Also, write the number of electrons, protons and neutrons they have.

Ans :

Hydrogen has three isotopes, i.e. these are the atoms of same element having same atomic number but different mass number.
Isotopes differ in number of neutrons.

Name of the Isotopes	Symbol	Mass Num.	Atomic Num.	Protons	Neutrons	Electrons
Protium	${}_1^1H$	1	1	1	0	1
Deuterium	${}_1^2D$ or ${}_1^2H$	2	1	1	1	1
Tritium	${}_1^3T$ or ${}_1^3H$	3	1	1	2	1

115. Name the following :
(i) two metals that react with cold water.
(ii) two metals which react with steam and displace hydrogen.

Ans :

(i) Na, K and Ca (any two).
(ii) Iron and Zinc.

116. How do the following react with water? Write balanced chemical equations:
(i) Potassium hydride
(ii) Calcium hydride

Ans :

(i) $KH + H_2O \longrightarrow KOH + H_2$
(ii) $CaH_2 + H_2O \longrightarrow Ca(OH)_2 + H_2$

THREE MARKS QUESTIONS

117. Metallic hydrides react with water to produce liquid 'A' and gas 'B'. In this context, answer the following questions.
(i) Identify 'A' and 'B'.
(ii) What is the effect of adding neutral litmus solution to 'A'?
(iii) What do you observe when burning splinter comes in contact with gas 'B'?

Ans :

(i) 'A' = Metallic hydroxide
'B' = Hydrogen
(ii) It turns blue
(iii) The splinter extinguishes and the gas burns with a popping sound.

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98. Give reasons :-
(i) Nitric acid is avoided in the preparation of hydrogen.
(ii) Only granulated zinc is used for the preparation of hydrogen.

Ans :
(i) As nitric acid is a strong oxidizing agent.
(ii) As granulated zinc contains the impurities of copper which act as a catalyst during the reaction.

99. State whether the following statements are True or False.
(i) Hydrogen is neutral towards litmus.
(ii) Normal hydrogen is deuterium.
(iii) Molecular hydrogen is a powerful reducing agent than nascent hydrogen.
(iv) Zinc reacts with caustic alkalies to liberate hydrogen.
(v) Chlorine reacts moderately with hydrogen in diffused sunlight.

Ans :
(i) True
(ii) False
(iii) False
(iv) True
(v) True

TWO MARKS QUESTIONS

100. A student collects a gas over water and observes that it burns with a 'pop' sound. He concludes that the gas is oxygen.
Do you agree? Give reasons.

Ans :
No.
1. The 'pop' sound is the characteristic test of hydrogen.
2. Oxygen supports combustion but does not burn with a pop sound.

101. During an experiment, a teacher accidentally collects hydrogen immediately after setting up the apparatus. Why may the result be dangerous?

Ans :
1. The first gas collected contains air mixed with hydrogen.
2. Hydrogen-air mixture is explosive and may cause an explosion on ignition.

102. Two isotopes of hydrogen contain the same number of protons but different numbers of neutrons. What conclusion can you draw about isotopes?

Ans :
1. Isotopes have the same atomic number.
2. They differ in mass number due to different numbers of neutrons.

103. A student says, "Hydrogen should be placed only with alkali metals because it has one valence electron."Identify one flaw in the statement.

Ans :
1. Hydrogen also resembles halogens by gaining one electron.
2. Therefore, it cannot be compared only with alkali metals.

104. A chemist wants to prepare hydrogen using copper and dilute hydrochloric acid. Predict the outcome.

Ans :
1. Hydrogen will not be produced.
2. Copper is less reactive than hydrogen and cannot displace it from acids.

105. A gas turns anhydrous copper sulphate from white to blue after combustion. What can be inferred about the product formed?

Ans :
1. Water has been formed.
2. Water turns anhydrous copper sulphate blue.

106. Hydrogen and chlorine both exist as H_2 and Cl_2 molecules. What property of these elements does this illustrate?

Ans :
1. It shows that both elements are diatomic.
2. Their molecules contain two atoms each.

107. A student uses concentrated sulphuric acid instead of dilute sulphuric acid to prepare hydrogen from zinc. Why is this incorrect?

Ans :
1. Concentrated sulphuric acid acts as an oxidising agent.
2. It may not liberate hydrogen normally and can produce other products.

108. A metal oxide changes from black to reddish-brown when heated in hydrogen. What has happened?

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contains the impurities of (ii) _____, (iii) _____, (iv) _____, (v) _____ (vi) _____ and (vii) _____. The impure hydrogen is passed through silver nitrate solution to remove (viii) _____ and (ix) _____. Then the impure hydrogen is passed through lead nitrate solution to remove (x) _____. Then finally hydrogen is passed through potassium hydroxide solution and anhydrous calcium chloride to remove (xi) _____, (xii) _____, (xiii) _____ and (xiv) _____ respectively to get (xv) _____ hydrogen.

Ans :

(a) (i) yellow (ii) zinc (iii) nascent (iv) yellow (v) pale green (vi) reduction

(b) (i) copper oxide (ii) pinkish red (iii) reducing agent

(c) (i) zinc (ii) arisine (iii) phosphine (iv) nitrogen dioxide (v) carbon dioxide (vi) sulphur dioxide (vii) moisture (viii) arsine (ix) phosphine (x) hydrogen suphide (xi) carbon dioxide (xii) sulphur dioxide (xi) nitrogen dioxide (xii) moisture (xi) pure.

88. Fill in the blanks.

(i) Nascent hydrogen is a powerful _____ agent.

(ii) Pure hydrogen burns in pure oxygen with _____ flame.

(iii) Water gas is a mixture of _____ and _____.

(iv) Nitric acid only gives hydrogen on reaction with _____ and _____.

(v) _____ reacts reversibly with steam.

(vi) Although aluminium is highly _____ element yet its reaction with water and dilute acids is _____.

(vii) During the electrolysis of acidulated water _____ is obtained at cathode and _____ is obtained at anode.

(viii) The process of addition of hydrogen is _____ which takes place in the presence of _____ catalyst.

(ix) Metallic hydrides are quiet _____ and reacts with water to liberate _____.

(x) Hydrogen is a _____ gas but _____ of combustion.

Ans :

(i) reducing
(ii) pale blue
(iii) carbon monoxide, hydrogen
(iv) magnesium, manganese
(v) iron
(vi) electropositive, slow
(vii) hydrogen, oxygen
(viii) hydrogenation, nickel
(ix) unstable, hydrogen
(x) combustible, not a supporter

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89. Fill in the blanks:

(i) _____ zinc is used for the preparation of hydrogen gas.

(ii) Hydrogen forms _____ mixture with air.

(iii) _____ solution is used to remove arsine and phosphine.

(iv) Lead nitrate solution is used to remove _____.

(v) _____ solution is used to remove sulphur dioxide, oxides of nitrogen, etc.

Ans :

(i) Granulated
(ii) explosive
(iii) Silver nitrate
(iv) hydrogen sulphide
(v) Potassium hydroxide.

90. Fill in the blanks:

(i) _____ is the most abundant element found in the sun and many stars.

(ii) Hydrogen forms _____ ions just like halogens.

(iii) Valence electron in hydrogen is _____.

(iv) Like alkali metals, hydrogen acts as _____ agent.

Ans :

(i) Hydrogen (ii) uninegative (iii) one (iv) reducing.

91. Fill in the blanks:

(i) Hydrogen is neutral to _____.

(ii) The process in which ammonia is manufactured is called _____.

(iii) Ethene reacts with hydrogen to form _____.

(iv) Hydrogen burns with a _____ flame.

(v) Catalyst employed in hydrogenation is _____.

Ans :

(i) Litmus
(ii) Haber's process

118. Write balanced chemical equations only for the reaction of hydrogen with

(i) Oxygen (ii) Sulphur
(iii) Chlorine (iv) Copper oxide
(v) Ethene.

Ans :

(i) $2H_2 + O_2 \longrightarrow 2H_2O$

(ii) $H_2 + S \longrightarrow H_2S$

(iii) $H_2 + Cl_2 \longrightarrow 2HCl$

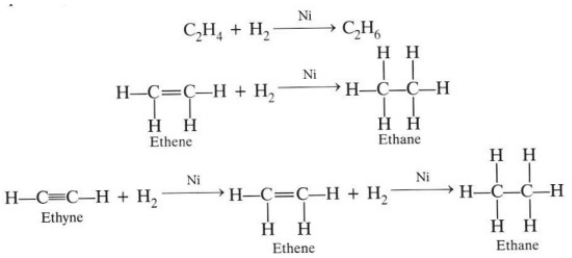
(iv) $CuO + H_2 \longrightarrow Cu + H_2O$

(v) $C_2H_4 + H_2 \longrightarrow C_2H_6$

119. Define hydrogenation giving an example.

Ans :

Hydrogenation: It is the process of addition of hydrogen to alkenes and alkynes in the presence of nickel as a catalyst. In this process, the unsaturated hydrocarbon gets converted to saturated hydrocarbon.



120. Name two metals which will displace hydrogen from strong caustic alkalies. Write chemical equations in support of your answer.

Ans :

Zinc (Zn) and Aluminium (Al)

$$Zn + \underset{\text{conc.}}{2NaOH} \xrightarrow{\text{boiled}} \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2$$

$$Zn + \underset{\text{conc.}}{2KOH} \xrightarrow{\text{boiled}} \underset{\text{Potassium zincate}}{K_2ZnO_2} + H_2$$

$$2Al + \underset{\text{conc.}}{2NaOH} + 2H_2O \xrightarrow{\text{boiled}} \underset{\text{Sodium aluminate}}{2NaAlO_2} + 3H_2$$

$$2Al + \underset{\text{conc.}}{2KOH} + 2H_2O \xrightarrow{\text{boiled}} \underset{\text{Potassium aluminate}}{2KaAlO_2} + 3H_2$$

121. State three precaution necessary for the collection of hydrogen.

Ans :

The necessary precautions are as follows:

(i) The apparatus used should be airtight.
(ii) Lower end of this the funnel should dip in the acid otherwise gas will escape from thistle funnel.
(iii) The apparatus should be kept away from the flame.

122. Name the impurities present in hydrogen gas obtained by the reaction of granulated zinc on dil. H_2SO_4 and how are these impurities removed.

Ans :

For the purification of hydrogen, the impure gas is passed through

(a) Silver nitrate solution: To absorb arsine and phosphine.
(b) Lead nitrate solution: To absorb hydrogen sulphide.
(c) Potassium hydroxide solution: To absorb carbon dioxide, sulphur dioxide and nitrogen dioxide.
(d) Anhydrous calcium chloride: To absorb moisture.

123. Write the equation for the formation of water gas.

Ans :

$$C + H_2O \xrightarrow{170^\circ C} \underset{\text{Water gas}}{\underline{CO + H_2}}$$

124. Name the following:

(i) Metal which burns with a lilac flame.
(ii) Metal which melts into a silvery globule and darts on the surface.
(iii) Metal which reacts reversibly with steam.
(iv) Metal which lies on the top of reactivity series.

Ans :

(i) Potassium
(ii) Sodium
(iii) Iron
(iv) Potassium

125. A student uses copper, zinc and magnesium separately with dilute hydrochloric acid to prepare hydrogen.

(a) Which metal will not produce hydrogen?
(b) Which metal will produce hydrogen most rapidly?
(c) Which metal is preferred in the laboratory and why?

Ans :

(a) Copper will not produce hydrogen.
(b) Magnesium will produce hydrogen most rapidly.

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CHAPTER 7

Study of Gas Laws

SUMMARY

1. MATTER

Everything around us — whether it is a stone, water, air or fire — is made up of matter. Anything that has weight and occupies space is called matter. Matter exists in different forms in nature and can be observed and experienced through our senses. Gas is also a matter or we can say that gas is a state of matter. Matter exists in three physical states — solid, liquid and gas. Each state of matter has its own distinct physical properties and behaviour. The study of matter and its different states helps us understand the physical and chemical changes that take place around us in everyday life.

1.1 States of Matter

Matter exists in nature in different physical forms known as states of matter. Each state of matter has its own unique set of properties that distinguish it from the others. There are three states of matter which are as follows::

(i) Solid
(ii) Liquid
(iii) Gas.

The three states of matter differ from each other in terms of their physical properties such as shape, volume, compressibility, intermolecular forces and the arrangement of their particles. A comparison of the properties of solid, liquid and gas are as follows:

	Solid	**Liquid**	**Gas**
(1)	Solids have definite shape and definite volume.	Liquids have no definite shape. They take the shape of the container but they have definite volume.	Gases have neither definite shape nor definite volume.
(2)	In solids, the molecules are closely packed.	In liquids, the molecules are loosely packed.	In gases, the molecules are far apart from each other.
(3)	In solids, the intermolecular space is minimum.	In liquids, the intermolecular space is more than solids.	In gases, the intermolecular space is maximum.
(4)	In solids, the intermolecular force of attraction is maximum.	In liquids, the intermolecular force of attraction is less than solids.	In gases, the intermolecular force of attraction is minimum or negligible.
(5)	Solids cannot flow,	Liquids flow from higher level to lower level.	Gases flow freely in all directions.

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2. CHARACTERISTICS OF GASES

Gases are one of the three fundamental states of matter and they behave very differently from solids and liquids. The general characteristics of gases can be explained on the basis of the kinetic theory of gases, which states that gas molecules are in a state of continuous random motion. The important characteristics of gases are as follows:

(i) Gases have neither definite shape nor definite volume: The molecules in gases are far apart from each other, therefore, intermolecular force of attraction is minimum and hence gases occupy the entire space in the container.

(ii) Gases are highly compressible: As the gases have maximum intermolecular space, therefore, on compressing, the gas molecules come closer to each other and thereby decreasing the volume.

(iii) Gases have minimum density: As gases have the smallest mass per unit volume, therefore, they have the minimum density.

(iv) Gases easily undergo diffusion: Gases readily undergo intermixing when kept

FOUR MARKS QUESTIONS

135. From the list of metals given below choose the metal which fits into the description given below:
Iron, zinc, sodium, silver, magnesium, lead.

(i) A metal which reacts very slowly with dilute hydrochloric acid initially but after sometime reaction stops.
(ii) A metal that reacts reversibly with steam.
(iii) A metal which reacts vigorously with cold water.
(iv) A metal which does not react with dilute acid or water.
(v) A metal which reacts both with acids and alkalies to displace hydrogen.

Ans :

(i) Lead (ii) Iron (iii) Sodium
(iv) Silver (v) Zinc.

136. When neutral gas 'A' which burns with popping sound is passed through boiling yellow non-metal 'B' it forms gas 'C'.

(i) Identify A, B and C.
(ii) Give balanced chemical equation for the reaction.
(iii) Give the characteristic odour of gas 'C'.
(iv) Give the confirmatory test of gas 'C'.
(v) Name the oxidation product of gas 'A'. Give two tests for the named product.

Ans :

(i) A = Hydrogen B = Sulphur
C = Hydrogen sulphide

(ii) $\underset{\text{'A'}}{H_2} + \underset{\substack{\text{boiling}\\ \text{'B'}}}{S} \longrightarrow \underset{\text{'C'}}{H_2S}$

(iii) Rotten egg smell.
(iv) Gas 'C' turns lead acetate solution black.
(v) The oxidation product of gas 'A' is water.
The two tests for water are:
(a) It turns anhydrous copper sulphate from white to blue.
(b) It turns anhydrous cobalt chloride from blue to pink.

137. Name the process by which hydrogen is manufactured. Give all details of the process.

Ans :

Bosch Process: This process involves the following two steps:

(i) Preparation of water gas: When superheated steam at a temperature of 170°C is passed over white hot charcoal it forms equivolume mixture of carbon monoxide and hydrogen called water gas. The reaction for the formation of water gas is endothermic in nature.

$$\underset{\substack{\text{White}\\ \text{hot}\\ \text{charcoal}}}{C} + \underset{\substack{\text{Super}\\ \text{heated}\\ \text{steam}}}{H_2O} \xrightarrow{170^\circ C} \underbrace{CO + H_2}_{\text{Water gas}}$$

(ii) Removal of impurities (carbon monoxide) from water gas: Water gas formed is mixed with twice the volume of steam and passed over the catalyst, which is a mixture of ferric oxide and chromium oxide (promoter) at a temperature of 450°C, carbon monoxide gets oxidized to carbon dioxide.

$$CO + H_2 + H_2O \xrightarrow[450^\circ C]{Fe_2O_3/Cr_2O_3} 2H_2 + CO_2$$

The above reaction is called the water gas shift reaction.
The hydrogen obtained by this process contains the impurities of carbon monoxide in traces and carbon dioxide. Carbon monoxide can be removed by passing it through ammoniacal cuprous chloride solution. Carbon dioxide can be removed by passing through cold water under pressure.

138. Hydrogen obtained during its laboratory preparation contains certain impurities. Name the impurities and how these impurities can be removed?

Ans :

Hydrogen obtained contains the impurities of the following gases:
Sulphur dioxide – SO_2
Carbon dioxide – CO_2
Water vapour – H_2O
Hydrogen sulphide – H_2S
Arsine – AsH_3
Phosphine – PH_3
Nitrogen dioxide – NO_2
For the purification of hydrogen, the impure gas is passed through

(a) Silver nitrate solution: To absorb arsine and phosphine.
(b) Lead nitrate solution: To absorb hydrogen sulphide.
(c) Potassium hydroxide solution: To absorb carbon dioxide, sulphur dioxide and nitrogen dioxide.
(d) Anhydrous calcium chloride: To absorb moisture.

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(c) Zinc is preferred because it reacts at a moderate rate and allows easy collection of hydrogen.

126. During an experiment, hydrogen collected in a gas jar produces a loud explosion when a burning splint is brought near it.
(a) What does this indicate about the gas collected?
(b) Why did the explosion occur?
(c) What precaution should have been taken?

Ans :
(a) The gas contained hydrogen mixed with air.
(b) Hydrogen forms an explosive mixture with air.
(c) Air should have been allowed to escape before collecting hydrogen.

127. Hydrogen is placed in Group 1 of the periodic table, yet many chemists consider it unique. Give three reasons.

Ans :
(i) It has one valence electron like alkali metals.
(ii) It can gain one electron like halogens.
(iii) Therefore, it shows similarities with both Group 1 and Group 17 elements.

128. A black powder turns reddish-brown when heated in a stream of hydrogen.
(a) Identify the black powder.
(b) Name the reddish-brown substance formed.
(c) What property of hydrogen is demonstrated?

Ans :
(a) Copper oxide (CuO)
(b) Copper (Cu)
(c) Hydrogen acts as a reducing agent.

129. A chemist passes impure hydrogen through potassium hydroxide solution and then through anhydrous calcium chloride. State the purpose of each step.

Ans :
(i) Potassium hydroxide removes acidic impurities such as carbon dioxide and sulphur dioxide.
(ii) Anhydrous calcium chloride removes moisture.
(iii) Dry and purified hydrogen is obtained.

130. Study the following isotopes:
X → 1 proton, 0 neutron
Y → 1 proton, 1 neutron
Z → 1 proton, 2 neutrons
(a) Name X, Y and Z.
(b) Why are they called isotopes?

Ans :
(a) X – Protium, Y – Deuterium, Z – Tritium.
(b) They are called isotopes because they have the same atomic number but different mass numbers.

131. A student says, "Hydrogen should support combustion because it burns readily."
Do you agree? Give reasons.

Ans :
(i) No, I do not agree.
(ii) Hydrogen is combustible but not a supporter of combustion.
(iii) It burns itself but does not help other substances to burn.

132. Explain why hydrogen is collected by downward displacement of water and not by upward displacement of air.

Ans :
(i) Hydrogen is practically insoluble in water.
(ii) Collection over water prevents mixing with air.
(iii) This avoids the formation of an explosive hydrogen-air mixture.

133. A scientist discovers a new isotope of hydrogen having one proton and three neutrons.
(a) Will it still be hydrogen?
(b) Give a reason.
(c) What will change in comparison to ordinary hydrogen?

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Ans :
(a) Yes.
(b) The element remains hydrogen because it has one proton.
(c) Its mass number will be different.

134. Hydrogen and chlorine react in diffused sunlight but explode in direct sunlight.
Explain this behaviour.

Ans :
(i) Chlorine has a strong affinity for hydrogen.
(ii) In diffused sunlight, the reaction occurs slowly to form hydrogen chloride.
(iii) In direct sunlight, the reaction becomes very rapid and explosive

Ans :

(i) A: Nitrogen
B: Hydrogen
C: Ammonia

(ii) Haber's process:

$$N_2 + 3H_2 \underset{450-500\,^\circ C,\ 200-1000\ atm}{\overset{Fe-Mo}{\rightleftharpoons}} 2NH_3$$

(iii) (a) It turns blue.
(b) It gives dense white fumes.

144. Rohit was studying the reduction of metallic oxides in the school chemistry laboratory. He set up an experiment where he passed dry hydrogen gas over heated black copper (II) oxide inside a hard glass tube. He observed a visible colour change in the solid residue left in the tube. He also noticed droplets of a colourless liquid condensing on the cooler parts of the glass tube. His teacher instructed him to write the ionic equations to understand the transfer of electrons occurring in this process.

(a) Name the colour of the solid residue left in the hard glass tube after the reaction.

(b) Write a balanced chemical equation with state symbols for the reaction taking place in the glass tube.

(c) Define reduction in terms of the electronic concept and write the reduction half-reaction occurring in Rohit's experiment.

Ans :

(a) The colour of the solid residue left in the hard glass tube changes from black to reddish brown due to the formation of copper.

(b) The balanced chemical equation for the reaction is: $CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$.

(c) 1. In the electronic concept, reduction is defined as a chemical process in which an atom or an ion gains electrons.

2. The reduction half-reaction in this experiment is: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$.

145. Meera was given a sample of aluminium powder and a concentrated solution of caustic soda during her practical assessment. She placed the aluminium powder into a conical flask and poured the alkali over it. Almost immediately, she observed a brisk effervescence with the release of a colourless, odourless gas. She brought a burning matchstick near the mouth of the flask, and the gas burned with a pale blue flame, producing a distinctive pop sound. Meera recorded these observations to identify the specific nature of the metal provided to her.

(a) Name the specific chemical nature of aluminium that allows it to react with both acids and alkalis to evolve the gas observed by Meera.

(b) Write a balanced chemical equation with state symbols for the reaction between aluminium and caustic soda solution.

(c) State why dilute nitric acid cannot be used in place of caustic soda to prepare this gas from aluminium.

Ans :

(a) Aluminium is amphoteric in nature, meaning it can react with both acids as well as with alkalis to evolve hydrogen gas.

(b) 1. The reactants are aluminium, sodium hydroxide, and water, which combine to form sodium aluminate and hydrogen gas.

2. The balanced chemical equation is:

$$2Al(s) + 2NaOH(aq) + 2H_2O(l) \rightarrow 2NaAlO_2(aq) + 3H_2(g).$$

(c) Nitric acid is a powerful oxidising agent, and the oxygen formed by its decomposition oxidises the produced hydrogen to form water, defeating the reaction's purpose.

146. Arjun was revising the first chapter of his chemistry textbook concerning the classification of elements. He noticed that the very first element in the periodic table has an atomic number of one and possesses just one electron in its valence shell. He read that this element exhibits a dual nature, making its placement somewhat unique. While discussing this with his study group, Arjun argued that the element behaves like the members of Group IA in some chemical reactions, but its atomicity and physical state strongly resemble the elements found in Group VIIA.

(a) Compare this element with the halogens on the basis of physical state and atomicity.

(b) Give two points of similarity between this element and alkali metals regarding their valence electrons and the formation of ions.

Ans :

(a) 1. Physical state: Like the halogens fluorine and chlorine, hydrogen also exists entirely as a gas under standard conditions.

2. Atomicity: Hydrogen and halogens both exist in the form of diatomic molecules, such as H_2, F_2, and Cl_2.

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(b) 1. Valence electrons: Both hydrogen and alkali metals have exactly one electron present in their outermost orbit or valence shell.
2. Ion formation: Each can form a cation, which is a positive ion, by losing one electron, demonstrating an electropositive character.

147. Sunita set up a specialized apparatus to study the combination of non-metals in the presence of external energy sources. In her first trial, she passed a stream of pure dry hydrogen gas through a flask containing molten sulphur. She detected the formation of a new gas with a highly distinct odour. In her second trial, she mixed equal volumes of hydrogen and chlorine gases in a sealed glass container and left it in diffused sunlight, noting that the reaction proceeded slowly compared to the explosive reaction that occurs under direct sunlight.

(a) Write a balanced chemical equation with state symbols for the reaction between hydrogen and molten sulphur, and name the product formed.

(b) Write a balanced chemical equation with state symbols for the reaction between hydrogen and chlorine, and state what happens if this mixture is exposed to direct sunlight.

Ans :

(a) 1. The balanced chemical equation for the reaction is: $H_2(g) + S(l) \rightarrow H_2S(g)$.
2. The gaseous product formed by passing hydrogen through molten sulphur is named hydrogen sulphide.

(b) 1. The balanced chemical equation for the reaction is: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$.
2. If the mixture of hydrogen and chlorine is exposed to direct sunlight, they react explosively rather than slowly.

148. Tarun visited a large-scale industrial chemical plant during an educational tour. The plant manager explained that they produce a highly combustible gas industrially using specially constructed furnaces known as converters. Tarun observed a process where steam was pushed over red-hot coke at a temperature of 1000°C to produce a specific gaseous mixture. The manager further detailed that this mixture is subsequently mixed with excess steam and passed over heated ferric oxide, which acts as a catalyst, along with chromic oxide to increase the yield of the desired fuel gas.

(a) Name the gaseous mixture produced when steam is pushed over red-hot coke in the converter.

(b) Write a balanced chemical equation with state symbols for the reaction occurring over the heated ferric oxide catalyst.

(c) State the specific role of chromic oxide in this industrial manufacturing process.

(d) Name the chemical solution through which the final mixture is passed to remove carbon dioxide gas.

Ans :

(a) The gaseous mixture produced by passing steam over red-hot coke at 1000°C is known as water gas, consisting of carbon monoxide and hydrogen.

(b) The balanced chemical equation for the exothermic reaction is:

$$(CO + H_2)(g) + H_2O(g) \rightarrow CO_2(g) + 2H_2(g).$$

(c) In the Bosch process, chromic oxide (Cr_2O_3) acts as a promoter to enhance the efficiency of the ferric oxide catalyst.

(d) The final gaseous mixture is passed through a caustic potash solution, which removes carbon dioxide by reacting with it.

149. Neha was preparing a historical presentation for her school's science exhibition on the earliest known combustible gases. She read about a scientist in 1493 who stated that an air arises which bursts forth like the wind when sulphuric acid acts on iron. She then learned that another prominent chemist in 1766 actually prepared this gas from iron and diluted acids, successfully establishing its elementary nature. Neha also researched the natural distribution of this element, discovering that it constitutes a major percentage of volcanic gases and is widely present in plant and animal tissues in a combined state.

(a) Name the scientist who established the elementary nature of this gas in 1766.

(b) State the name given to this gas by the scientist in 1766 due to its combustible nature.

(c) State the exact percentage of this element present in the earth's crust.

(d) Name the scientist who finally named this gas in 1783 based on its ability to form water.

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Ans :

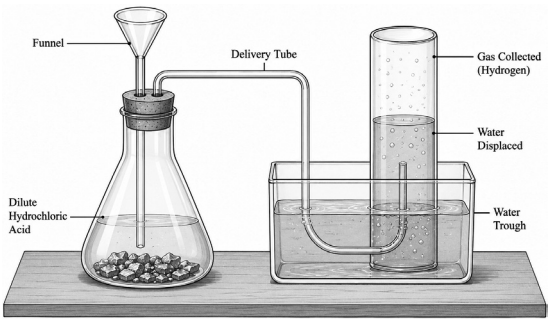
(a) The scientist who prepared the gas from iron and diluted acids and established its elementary nature in 1766 was Henry Cavendish.

(b) Due to its highly combustible nature, Henry Cavendish originally called this newly discovered gas "inflammable air".

(c) According to geological data, hydrogen is found in traces in a free state, comprising exactly 0.98% of the earth's crust.

(d) The scientist who named the gas "hydrogen" in 1783, from a Greek word meaning water former, was Lavoisier.

150. Rahul was performing a gas collection experiment on his laboratory bench. He carefully assembled the glass apparatus and poured a dilute acid through the vertical funnel. He observed brisk effervescence inside the primary flask, and shortly after, bubbles began displacing the water inside the inverted cylinder.



(a) Identify the specific solid metallic granules placed at the bottom of the flat-bottom flask.

(b) Write a balanced chemical equation with state symbols for the reaction occurring in the flask using dilute hydrochloric acid.

(c) State the structural reason why the end of the long stem funnel must be dipped under the acid, and explain why concentrated sulphuric acid is not used in this apparatus.

Ans :

(a) The solid metallic granules preferred and placed at the bottom of the flat-bottom flask are granulated zinc.

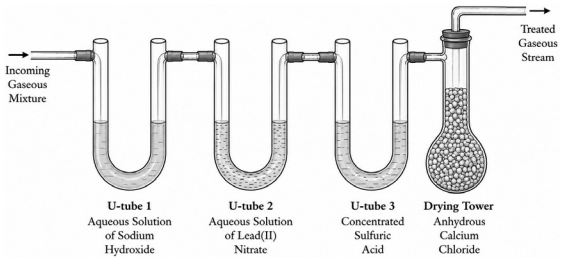
(b) The balanced chemical equation for the reaction is:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g).$$

(c) 1. The end of the thistle funnel must be dipped under the acid to prevent the evolved gas from escaping upward through the funnel.

2. Concentrated sulphuric acid is not used because it combines with hydrogen, negating the reaction's intended outcome and failing to dry it.

151. Kavita was tasked with isolating pure dry gas from a crude mixture containing several volatile impurities. She routed the impure gaseous stream through a sequential series of three U-shaped tubes containing different chemical reagents. She monitored the final output to ensure all traces of arsine, phosphine, and acidic oxides were entirely removed before the final collection step.



(a) Name the specific liquid solution present in the first U-tube used to remove arsine and phosphine impurities.

(b) Write the balanced chemical equations with state symbols showing the removal of carbon dioxide and sulphur dioxide by the solution in the third U-tube.

(c) Identify the solid substance packed in the final vertical drying tower that draws out water vapour from the gas.

Ans :

(a) The specific liquid solution present in the first U-tube that removes arsine and phosphine is silver nitrate solution.

(b) 1. Carbon dioxide is removed by caustic potash:

$$CO_2(g) + 2KOH(aq) \rightarrow K_2CO_3(aq) + H_2O(l).$$

2. Sulphur dioxide is removed by caustic potash:

$$SO_2(g) + 2KOH(aq) \rightarrow K_2SO_3(aq) + H_2O(l).$$

(c) The solid crystalline substance packed in the vertical drying tower to remove water vapour is anhydrous calcium chloride.

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139. A black metallic oxide 'A' on reaction with colourless and odourless gas 'B' forms pinkish red metal and colourless liquid 'D'.
(i) Identify A, B, C and D.
(ii) Give balanced chemical equation for the reaction.
(iii) What is the purpose of gas 'B'?
(iv) Give two tests for colourless liquid 'D'.

Ans :
(i) A = CuO, B = H_2, C = Cu, D = H_2O
(ii) $CuO + H_2 \longrightarrow Cu + H_2O$
(iii) It acts are reducing agent.
(iv) It turns anhydrous copper sulphate from white to blue and Anhydrous cobalt chloride from blue to pink.

140. How does hydrogen resemble to the alkali metal?

Ans :

Hydrogen resembles the alkali metals in the following ways:
(i) Electronic Configuration: Like alkali metals, hydrogen has also got one electron in its valence shell.
(ii) Formation of Cations: Like alkali metals, hydrogen loses electron and forms cation.

$$H - e^- \longrightarrow H^+ \text{ (Hydrogen)}$$

$$Na - e^- \longrightarrow Na^+ \text{ (Alkali metal)}$$

(iii) Formation of Compounds: Hydrogen readily forms stable compounds with oxygen, sulphur and chlorine.

H_2O = Water

H_2S = Hydrogen sulphide

HCl = Hydrogen chloride

In the similar way, the alkali metals form oxides, sulphides and chlorides

Na_2O = Sodium oxide

Na_2S = Sodium sulphide

NaCl = Sodium chloride

(iv) Hydrogen burns in oxygen to form water (neutral oxide).

$$2H_2 + O_2 \longrightarrow 2H_2O$$

141. Why zinc is preferred over other metals for laboratory preparation of hydrogen? Write equation.

Ans :

Zinc is preferred to other metals because sodium and potassium react explosively or violently with cold water or dilute acids. In calcium and magnesium, the liberation of hydrogen is so rapid that it cannot be collected. Aluminium gets coated with the thin but tough layer of oxide which prevents the reaction of metal with water and dilute acids.
In iron, the liberation of hydrogen is very slow and as copper lies below hydrogen in activity series so, it cannot displace hydrogen from dilute acids.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$$

142. The following questions are related to the manufacture of hydrogen by the Bosch process.
(i) Give equation for the preparation of water gas.
(ii) Why the temperature of charcoal falls down during the formation of water gas?
(iii) Give equation for the water gas shift reaction.
(iv) How are the above named gases removed from hydrogen?

Ans :

(i) $\underset{\text{White hot charcol}}{C} + \underset{\text{Super heated steam}}{H_2O} \xrightarrow{170^\circ C} \underset{\substack{\text{Equivolume mixture of CO and } H_2\text{(Water gas)}}}{\underline{CO + H_2}}$

(ii) The reaction of superheated steam with coke/charcoal is endothermic in nature, therefore, the temperature of charcoal falls down.

(iii) $\underset{\text{Water gas}}{\underline{CO + H_2}} + H_2O \xrightarrow[450^\circ C]{Fe_2O_3/Cr_2O_3} CO_2 + 2H_2$

(iv) Carbon dioxide is removed by passing it through water under pressure.
Carbon monoxide is removed by passing it through ammoniacal cuprous chloride solution.

CASE BASED QUEATIONS

143. Two neutral gases 'A' and 'B' undergo synthesis reaction to form a basic gas 'C'.
(i) Identify A, B and C.
(ii) Name the process by which gas 'C' is manufactured. Give balanced chemical equation also.
(iii) What do you observe when gas 'C' comes in contact with
(a) moist red litmus paper?
(b) concentrated hydrochloric acid?

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(a) Identify the small metallic lump floating on the liquid surface based on the observation in the scenario.

(b) State the density of this metal which causes it to float on the water's surface.

(c) State the exact colour of the flame produced by this specific metal when it catches fire in water.

(d) State the chemical nature of the final solution left in the trough after the metal has completely reacted.

Ans :

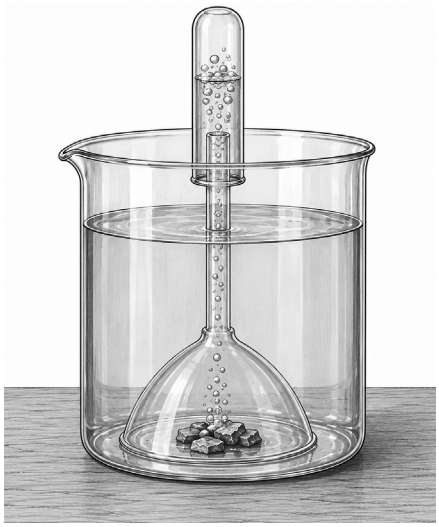
(a) The small metallic lump floating on the liquid surface is sodium, which reacts with cold water.

(b) The density of sodium metal is 0.97 g/cc, which is less than water, allowing it to float.

(c) When sodium catches fire during its reaction with cold water, it burns with a golden yellow flame.

(d) After the sodium completely reacts, the resulting solution formed in the trough is alkaline, colourless, soapy, and slightly warm.

155. Sneha was studying the reactivity gradient of alkaline earth metals with cold water. She placed a few metal granules into a beaker filled with water and inverted a glass apparatus over them to capture the evolved gas. Unlike the highly vigorous reactions she had seen with Group 1 metals, she observed that these granules sank to the bottom and reacted smoothly, gradually turning the clear water into a milky, turbid suspension.



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(a) Identify the solid metallic pieces resting at the bottom of the beaker under the inverted funnel.

(b) Write a balanced chemical equation with state symbols for the reaction taking place at the bottom of the beaker.

(c) State why the solid pieces sink to the bottom rather than float like potassium or sodium.

(d) State the colour change observed if red litmus paper is introduced into the milky, turbid solution left in the beaker.

Ans :

(a) The solid metallic pieces resting at the bottom of the beaker are calcium, which reacts smoothly with water.

(b) The balanced chemical equation for the reaction is:

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g).$$

(c) Calcium sinks in water because it is denser than water, unlike sodium and potassium which have densities lower than water.

(d) On introducing red litmus paper into the milky, turbid calcium hydroxide solution, the litmus paper turns blue, showing it is alkaline.

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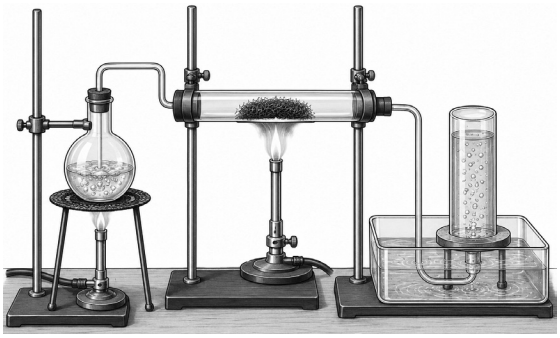
152. Manoj was investigating the reactivity of transition metals with water at elevated temperatures. He assembled a heating apparatus and passed hot vapours over a red-hot metal sample placed within a heat-resistant glass tube. He collected the resulting gas in a beehive shelf arrangement and noted that if the gas was not promptly removed, the metallic oxide formed would revert back to the original metal.



(a) Identify the fibrous metallic bundle placed inside the heated horizontal tube, and write a balanced chemical equation with state symbols for the reaction occurring there.

(b) State the name of the chemical process if the products are not allowed to escape, and name the solid oxide formed in the heated tube.

Ans :

(a) 1. The fibrous metallic bundle placed inside the heated silica glass tube is steel wool (iron).

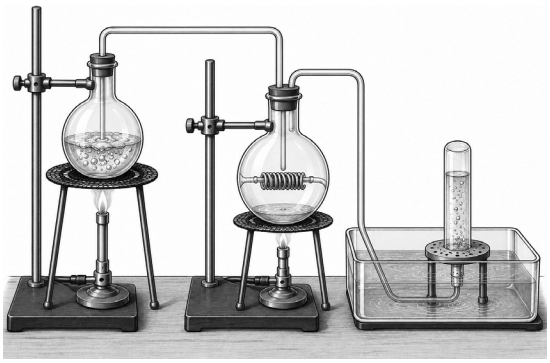
2. The balanced chemical equation is:

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g).$$

(b) 1. If the produced gas is not removed, the reaction proceeds backward, which is an example of a reversible reaction.

2. The solid oxide formed in the tube is triferric tetraoxide.

153. Priya was comparing the vigour of various alkaline earth metals when exposed to heated water vapour. She set up a dual-flask distillation train where the vapour generated in the first flask passed over a suspended coil of metal in the second flask. She observed that the metal coil burned with an intense white light and rapidly crumbled into a white ash as a highly combustible gas was expelled into the collection trough.



(a) Identify the coiled ribbon of metal suspended in the second flask, and describe the visual observation of its reaction with the incoming vapour.

(b) Write a balanced chemical equation with state symbols for the reaction occurring in the second flask, and state what happens to the solid product over a longer period.

Ans :

(a) 1. The coiled ribbon of metal suspended inside the heated second flask is a magnesium ribbon.

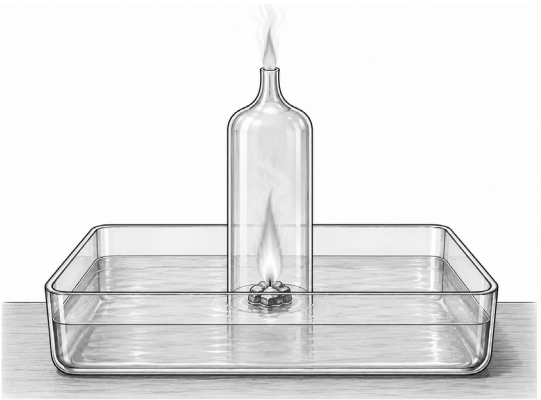
2. The metal burns in the steam with an intense white light, generating a white ash.

(b) 1. The balanced chemical equation for the reaction is:

$$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g).$$

2. When heated over a longer period of time, the white magnesium oxide formed completely crumbles.

154. Amit was conducting an alkali metal reactivity demonstration for his junior chemistry club. He carefully dropped a small metallic lump into an open glass trough containing cold water. He instructed the students to stand back, as the metal immediately darted across the surface, catching fire with a very distinct flame colour while releasing a fast stream of gas bubbles.



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in contact with each other to form homogeneous mixture as they have maximum intermolecular spaces.

3. GAS LAWS

Gases show a unique behaviour when subjected to changes in physical conditions such as pressure, temperature and volume. In order to understand and explain this behaviour, scientists formulated certain laws known as gas laws. Gas laws describe the behaviour of a gas under the conditions of pressure, temperature and volume. These laws establish a mathematical relationship between the physical properties of gases and help us predict how a gas will behave when one or more of these conditions are changed. The variables used during gas laws are the pressure (P), temperature (T) and volume (V).

3.1 Units of Measurement

In order to study the gas laws properly, it is essential to understand the units in which the physical quantities involved are measured. The three important variables used in gas laws are temperature, volume and pressure, and each of these quantities has its own specific units of measurement. The details of these units are as follows:

(i) Units of Temperature: Temperature is one of the most important variables in gas laws. The two commonly used units of temperature are:
(a) Celsius (°C)
(b) Kelvin (K)
Relationship between Celsius and kelvin:
$K = °C + 273$
$°C = K - 273$
For example; Conversion of temperature on the Celsius scale to the Kelvin scale:
(a) $0°C = 0 + 273 = 273K$
(b) $-273°C = -273 + 273 = 0K$
(c) $100°C = 100 + 273 = 373\ K$
(d) $200°C = 200 + 273 = 473K$

(ii) Units of Volume: Volume is the amount of space occupied by a gas. The commonly used units of volume are:
(a) Millilitre (mL)
(b) Cubic centimetre (cm3)
(c) Litre (L)
Relationship between litre, millilitre and cubic centimetre:

1 litre= 1000 mL = 1000 cm^3

1 mL = 1 cm^3

(iii) Units of Pressure: Pressure is the force exerted by gas molecules per unit area on the walls of the container. The commonly used units of pressure are:
(a) Atmosphere (atm)
(b) cm of Mercury (Hg) (cm of Hg)
(c) mm of Mercury (Hg) (mm of Hg)
Relationship between Atmosphere and Mercury:

1 atmosphere = 76 cm of Hg
= 760 mm of Hg
= 760 of Hg

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3.2 Boyle's law

Boyle's law states that at constant temperature, the volume of a given mass of a dry gas is inversely proportional to pressure.

$$V \propto \frac{1}{P} \qquad \text{(at constant } T\text{)}$$

where V = Volume of the dry gas,
P = Pressure on the gas

$$V = K\frac{1}{P} \qquad \text{(where } K \text{ is constant)}$$

$$PV = K$$

Hence, Boyle's law equation is $P_1 V_1 = P_2 V_2$

where P_1 = Initial pressure,
V_1 = Initial volume,
P_2 = Final pressure,
V_2 = Final volume

3.3 Charles' law

Pressure of an enclosed mass of a dry gas remaining constant, the volume of the gas is directly
proportional to absolute temperature. This law is known as Charles' law.

$$V \propto T \qquad \text{(at constant } P\text{)}$$

where V = Volume of the dry gas and
T = Temperature of the gas

$$V = KT \qquad \text{(where } K \text{ is constant)}$$

$$\frac{V}{T} = K$$

Hence, Charles' law equation is

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

of the pressure exerted by the gas inside the sealed flask.

16. A sealed gas container is cooled from 400 K to 200 K while pressure remains constant. What happens to its volume?
(A) Doubles
(B) Becomes half
(C) Remains same
(D) Becomes four times

Ans :(B)

According to Charles' law, volume is directly proportional to absolute temperature at constant pressure. When temperature decreases from 400 K to 200 K, it becomes half. Therefore, the volume also becomes half of its original value.

17. A student observes that air occupies the entire space inside a football. This shows that gases:
(A) Have definite shape
(B) Have definite volume
(C) Occupy the entire available space
(D) Cannot flow

Ans :(C)

Gas particles are far apart and move randomly in all directions. Due to negligible intermolecular forces, they spread throughout the container and occupy all available space, unlike solids and liquids which have fixed or limited volume.

18. 3. A gas occupies 500 cm^3 at 1 atm pressure. If pressure is increased to 5 atm at constant temperature, the volume becomes:
(A) 100 cm^3
(B) 250 cm^3
(C) 500 cm^3
(D) 1000 cm^3

Ans :(A)

(B) Boyle's law,

$$P_1V_1 = P_2V_2.$$

Therefore,

$$1 \times 500 = 5 \times V_2.$$

After solving, we get

$$V_2 = 100 \text{ cm}^3.$$

This demonstrates the inverse relationship between pressure and volume when temperature remains constant.

19. Which property of gases makes LPG easy to store in cylinders?
(A) Diffusion
(B) Low density
(C) Compressibility
(D) Fixed volume

Ans :(C)

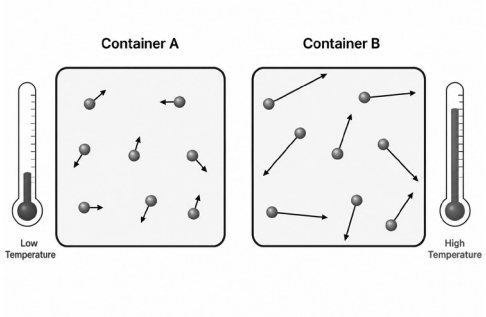
Gases have large intermolecular spaces and can be compressed into smaller volumes. This property allows large quantities of LPG to be stored safely in cylinders under high pressure for domestic and industrial use.

20. A bottle of perfume is opened in a classroom. Students at the back can smell it after some time. This is because gas particles:
(A) Are stationary
(B) Diffuse rapidly
(C) Sink to the bottom
(D) Have fixed positions

Ans :(B)

Gas particles are in continuous random motion. They spread from regions of higher concentration to lower concentration. This process, known as diffusion, causes the perfume smell to reach every part of the classroom.

21. The diagrams show the same number of gas molecules in two identical containers, A and B, at different temperatures. Which statement correctly interprets the information presented in the diagrams?



(A) Molecules in container A have higher average kinetic energy.
(B) The pressure in container B is lower than in container A.
(C) Molecules in container B have higher average kinetic energy.
(D) The temperature in container A is higher than in container B.

Ans : (C)

The length of the velocity vectors represents the speed of the gas molecules. The diagram shows that molecules in container B are moving faster than those in container A. Since the average kinetic energy of gas molecules is directly proportional to the absolute temperature, the

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3. According to the kinetic theory of gases, the physical pressure exerted uniformly in all directions by an enclosed gas completely arises from which specific action?
(A) Gravitational pull settling the molecules
(B) Constant collisions of gas molecules with the container walls
(C) Intermolecular strong forces of attraction
(D) Expansion of molecules upon rapid cooling

Ans : (B)

Constituent gas molecules exist in a continuous dynamic state of rapid and highly random microscopic motion. During this entirely unrestricted kinetic movement, they violently and frequently collide against the restrictive inner structural walls of their confining container, uniformly applying a continuous outward pressure.

4. A lab technician recorded measurements for different gases. The data is presented in the table below.

Measurement Description	Value	Unit
Volume of gas in a balloon	2	L
Pressure at sea level	76	mm Hg
Volume of a large gas cylinder	20	cm^3
Pressure measured by manometer	1.2	Pa

Which row shows a measurement with both a plausible value and a conventional unit for the described context?
(A) Volume of gas in a balloon
(B) Pressure at sea level
(C) Volume of a large gas cylinder
(D) Pressure measured by manometer

Ans :(A)

A balloon having a volume of 2 Litres is a reasonable measurement. Pressure at sea level is 760 mm Hg, not 76. A large gas cylinder would have a volume much greater than 20 cm^3 (which is 20 mL). A gas pressure of 1.2 Pascals is extremely low; atm or mm Hg would be more conventional.

5. What physical phenomenon fundamentally causes the significant cooling of a rapidly expanding gas transitioning from a region of high pressure strictly to a low-pressure region?
(A) Increase in absolute temperature
(B) Decrease in intermolecular distances
(C) Consumption of molecular kinetic energy to overcome residual attraction
(D) Complete cessation of random molecular motion

Ans : (C)

Whenever a compressed gas physically expands from an area of high concentrated pressure to a lower pressure region, intermolecular structural distances widen significantly. Overcoming these faint residual attractive forces rapidly consumes the kinetic energy of the molecules, directly causing a notably sharp temperature decrease.

6. On the traditional centigrade Celsius thermal measurement scale securely utilized by laboratory chemists, which specific precise absolute values exactly correspond to the established freezing and boiling points of pure water at one standard atmosphere?
(A) 32 degrees and 212 degrees
(B) 0 degrees and 100 degrees
(C) 273 degrees and 373 degrees
(D) 10 degrees and 110 degrees

Ans : (B)

On the traditional Celsius centigrade temperature measurement scale, which is fundamentally structured around the predictable physical phase transitions of pure water at exactly one standard atmosphere of ambient pressure, the absolute freezing point is defined as strictly zero degrees, while the boiling phase begins at one hundred degrees.

7. Identify the correct combination of elements that naturally exist as gases under normal atmospheric conditions from the list provided below
I. Hydrogen
II. Bromine
III. Radon
IV. Iodine
(A) I and II only
(B) I and III only
(C) II and IV only
(D) I, III and IV only

Ans : (B)

Among the listed chemical elements, only hydrogen and radon are naturally occurring pure gases under normal ambient temperature and atmospheric pressure conditions. Bromine characteristically exists as a dense liquid, while iodine naturally exists as a solid, strictly excluding them mathematically.

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8. A student investigates the properties of a fixed mass of air trapped in a syringe. The observations are tabulated below.

Step	Action on Syringe	Observation
1	The nozzle is sealed and the piston is pushed inwards.	Volume decreases.
2	The syringe is gently warmed over a flame.	Volume increases.

Which postulate of the Kinetic Molecular Theory best explains these two observations?

(A) Gas molecules are in constant random motion and collide with each other.
(B) The forces of attraction between gas molecules are negligible.
(C) Large intermolecular spaces exist and kinetic energy is proportional to temperature.
(D) The volume of individual gas molecules is negligible compared to the container volume.

Ans : (C)

Observation 1 (compressibility) is possible because of the large empty spaces between gas molecules, allowing them to be forced closer. Observation 2 (expansion) occurs because heating increases the average kinetic energy of the molecules, causing them to move faster and farther apart, thereby increasing the volume occupied by the gas.

9. **Assertion (A) :** Gases inherently possess significantly lower densities compared to solid and liquid states of matter.
Reason (R) : The vastly increased physical volume caused by very large intermolecular spatial gaps accounts perfectly for the extremely low density.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

The inherently weak internal intermolecular attractive forces present in gaseous states naturally result in excessively large physical gaps between randomly moving molecules, drastically increasing their overall spatial volume. Since material density mathematically equals mass divided by volume, this massive expansion directly creates exceptionally low densities.

10. While a standard scientific barometer reliably measures ambient atmospheric pressure, which highly specific specialized laboratory instrument is utilized to accurately quantify the physical pressure securely exerted exclusively by an enclosed laboratory gas?

(A) Hydrometer
(B) Thermometer
(C) Manometer
(D) Hygrometer

Ans : (C)

While general atmospheric pressure continuously exerted by the remarkably thick invisible blanket of environmental air is typically measured using a standard barometer, the distinct localized pressure forcefully exerted by a confined gas sample in an experimental container is accurately measured using a specialized manometer.

11. Match the fundamental measurable physical variables of an enclosed gas directly with their corresponding globally standardized metric units.

List–I (Variable)
P. Pressure
Q. Volume
R. Mass
S. Absolute Temperature
List–II (Standard Unit)
I. Kilogram
II. Cubic metre
III. Pascal
IV. Kelvin

(A) P-III, Q-II, R-I, S-IV
(B) P-II, Q-III, R-I, S-IV
(C) P-III, Q-I, R-II, S-IV
(D) P-I, Q-II, R-IV, S-III

Ans : (A)

In the globally accepted International System of Units, the primary standardized metric unit for measuring physical pressure is the universally recognized pascal. Consequently, spatial volume is properly measured in cubic metres, fundamental mass is precisely calculated in kilograms, and absolute thermodynamic temperature uses Kelvin.

12. In practical laboratory measurements, standard external atmospheric pressure is frequently mathematically expressed using the common metric bar unit. Which distinct exact numeric equivalent accurately relates one standard bar directly to the established atmospheric unit?

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(A) 0.0987 atm
(B) 1.013 atm
(C) 0.987 atm
(D) 10.13 atm

Ans : (A)

Although standard atmospheric pressure is conventionally expressed using the traditional atmospheric unit in typical chemical equations, the bar remains another universally standard metric measurement unit adopted today. Mathematically calculated, precisely one standard bar is formally defined as being exactly equivalent to zero point zero nine eight seven atmospheres.

13. A student collects data to verify Boyle's Law. The temperature is kept constant. Find the missing volume 'X'.

Pressure (atm)	Volume (L)
0.5	40
1.0	20
2.5	8
4.0	X

(A) 4.0
(B) 5.0
(C) 10.0
(D) 16.0

Ans : (B)

According to Boyle's law, for a fixed mass of gas at constant temperature, the product of pressure and volume is constant ($P_1V_1 = P_2V_2$). From the first row, the constant product is 0.5 atm × 40 L = 20 L-atm. For the last row, 4.0 atm × X = 20 L-atm. Solving for X gives X = 20 / 4.0 = 5.0 L.

14. Evaluate the following given descriptive statements carefully regarding the foundational microscopic postulates defining the universally accepted kinetic molecular physical theory of enclosed gases.

I. Gas particles strictly act as dimensionless point masses occupying essentially entirely negligible container volume.
II. Molecules permanently lose massive amounts of physical kinetic energy entirely during frequent random wall collisions.
III. Average internal molecular kinetic energy continuously perfectly remains directly mathematically proportional precisely to the surrounding ambient absolute environmental Kelvin temperature.
IV. Strong internal structural attractive cohesive forces permanently actively bind neighbouring moving gas molecules tightly closely directly safely securely entirely completely firmly together.

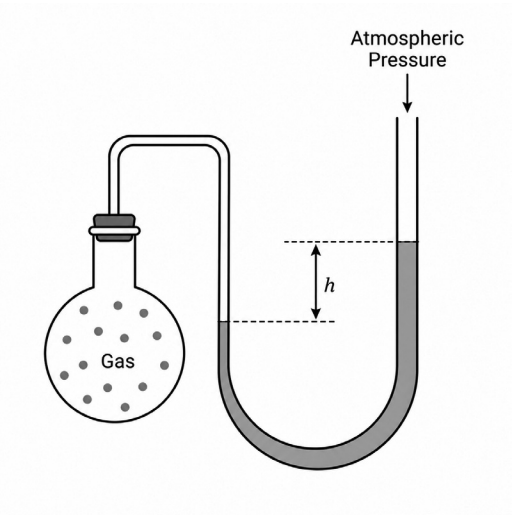
Which exact specific combination of statements is perfectly structurally conceptually factually completely entirely absolutely fundamentally scientifically correct?

(A) I and III only
(B) II and IV only
(C) I, II and III only
(D) I, III and IV only

Ans : (A)

The widely accepted kinetic molecular theory formally establishes that constituent gas molecules strictly act as tiny point masses possessing completely negligible volume. Furthermore, their rapid random container collisions are fundamentally perfectly elastic, confirming absolutely zero internal kinetic energy is ever physically lost, whilst attractive forces remain practically completely non-existent.

15. The difference in the liquid levels, marked 'h', is observed. What does this setup directly measure?



(A) The absolute temperature of the gas
(B) The pressure exerted by the gas
(C) The density of the gas
(D) The volume of the gas

Ans : (B)

The instrument shown is a manometer, which measures the pressure of a gas relative to atmospheric pressure. The height difference 'h' in the liquid columns indicates the difference between the gas pressure and atmospheric pressure. This allows for the direct determination

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41. A weather balloon is released from the ground. Its conditions at two different altitudes are recorded.

Location	Pressure (P)	Temperature (T)	Volume (V)
Ground Level	1.0 atm	27°C	200 L
Altitude Z	0.4 atm	-33°C	V_2

Calculate the approximate volume (V_2) of the balloon at Altitude Z.
(A) 160 L
(B) 250 L
(C) 400 L
(D) 667 L

Ans :(C)

First, convert temperatures to Kelvin:

$$T_1 = 27 + 273$$
$$= 300 \text{ K}$$

and $T_2 = -33 + 273$
$$= 240 \text{ K}.$$

Using the combined gas equation,

$$V_2 = (P_1V_1T_2)/(P_2T_1),$$

we substitute the values:

$$V_2 = (1.0 \text{ atm} \times 200 \text{ L} \times 240 \text{ K}) / (0.4 \text{ atm} \times 300 \text{ K})$$
$$= 48000 / 120 = 400 \text{ L}.$$

42. Which statement is correct regarding the three states of matter?
(A) Solids have maximum intermolecular space
(B) Liquids have stronger intermolecular forces than solids
(C) Gases have minimum intermolecular force of attraction
(D) Gases have definite volume

Ans :(C)

Gas particles are far apart and experience negligible intermolecular attraction. This allows gases to move freely and explains why they have neither definite shape nor definite volume.

43. Which of the following is an example of matter?
(A) Light
(B) Sound
(C) Air
(D) Heat

Ans :(C)

Explanation: Matter is anything that has mass and occupies space. Air may not be visible, but it occupies space and has weight. This can be observed when a balloon is inflated. Light, sound and heat are forms of energy and do not possess mass or occupy space. Therefore, air is classified as matter. The concept of matter includes solids, liquids and gases, all of which satisfy these two conditions.

44. Which state of matter has a definite shape and definite volume?
(A) Gas
(B) Liquid
(C) Solid
(D) Vapour

Ans :(C)

Explanation: In solids, particles are very closely packed and held together by strong intermolecular forces. As a result, solids maintain a fixed shape and a fixed volume. Examples include iron, wood and stone. Unlike liquids and gases, solids cannot flow and do not take the shape of their container. This rigid arrangement of particles is responsible for their characteristic properties.

45. Which state of matter has neither definite shape nor definite volume?
(A) Solid
(B) Liquid
(C) Gas
(D) Ice

Ans :(C)

Explanation: Gas particles are far apart and move freely in all directions. Due to very weak intermolecular forces, gases expand to fill the entire container in which they are kept. Therefore, gases do not have a fixed shape or volume. Examples include oxygen, hydrogen and carbon dioxide. Their ability to occupy all available space distinguishes them from solids and liquids.

46. In which state are molecules most closely packed?
(A) Gas
(B) Liquid
(C) Solid
(D) Plasma

Ans :(C)

Explanation: Solids possess the least intermolecular space and the strongest intermolecular forces. The particles are arranged very closely, giving solids rigidity and definite shape. Since movement of particles is highly restricted, solids are difficult to compress. This

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molecules in the higher-temperature container B possess higher average kinetic energy.

22. Which statement correctly compares solids and gases?
(A) Both have fixed shape
(B) Both have fixed volume
(C) Solids have stronger intermolecular forces than gases
(D) Gases have stronger intermolecular forces than solids

Ans :(C)

Solid particles are closely packed with strong intermolecular attraction. Gas particles are widely separated with negligible attraction. This difference explains why solids have fixed shape and volume while gases do not.

23. A temperature of 47°C is equal to:
(A) 273 K
(B) 300 K
(C) 320 K
(D) 347 K

Ans :(C)

To convert Celsius into Kelvin, add 273. Therefore, 47 + 273 = 320 K. Kelvin scale is used in gas law calculations because it represents absolute temperature.

24. The table shows the product of pressure (P) and volume (PV) for a fixed mass of an ideal gas as the pressure is varied at a constant temperature of 300 K.

Pressure (atm)	**Product PV (L-atm)**
1.0	24.6
1.5	24.6
2.0	24.6
2.5	24.6

What does the constant value of the product PV signify?
(A) The gas is obeying Charles's Law.
(B) The gas is obeying Boyle's Law.
(C) The temperature of the gas is not constant.
(D) The gas volume is directly proportional to pressure.

Ans :(B)

Boyle's Law states that for a fixed mass of a gas at constant temperature, the product of its pressure and volume is a constant. The table shows that as pressure changes, the product PV remains unchanged at 24.6 L-atm. This is the characteristic mathematical representation of Boyle's Law, confirming its validity for this gas.

25. A weather balloon rises high into the atmosphere and becomes larger. The most appropriate reason is:
(A) External pressure decreases with height
(B) Mass of gas increases
(C) Density becomes zero
(D) Molecules stop moving

Ans :(A)

(A) altitude increases, atmospheric pressure decreases. According to Boyle's law, a decrease in pressure causes an increase in volume if temperature remains nearly constant. Hence, the weather balloon expands as it rises.

26. A gas occupies 300 cm^3 at 300 K. If the temperature is increased to 600 K at constant pressure, the new volume will be:
(A) 150 cm^3
(B) 300 cm^3
(C) 600 cm^3
(D) 900 cm^3

Ans :(C)

According to Charles' law, volume is directly proportional to absolute temperature. Since the temperature doubles from 300 K to 600 K, the volume also doubles from 300 cm^3 to 600 cm^3.

27. During a laboratory experiment, a gas expands when heated. The most suitable explanation is that:
(A) Molecules stop moving
(B) Molecules move faster and spread apart
(C) Pressure becomes zero
(D) Density increases

Ans :(B)

Heating increases the kinetic energy of gas molecules. Faster-moving particles spread farther apart and occupy more space. As a result, the volume of the gas increases when pressure remains constant.

28. Which state of matter has the maximum intermolecular space and minimum density?
(A) Solid
(B) Liquid
(C) Gas
(D) Ice

Ans :(C)

Gas particles are separated by large distances

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Where V_1 = Initial volume,

V_2 = Final volume

T_1 = Initial temperature,

T_2 = Final temperature,

4. KELVIN SCALE:

The new temperature scale on which the zero is at $-273^{\circ}C$, such that each degree on it is equal to one degree on the Celsius is called the Kelvin scale.

4.1 Absolute zero:

It is the last or the lowest limit of temperature at which the volume becomes theoretically zero. The temperature for absolute zero is $-273^{\circ}C$. The standard temperature is 0 °C or 273 K. The standard pressure is 760 mm of Hg or 76 cm of Hg or 1 atmosphere.

5. GAS EQUATION

By combining Boyle's law and Charles' law, the perfect gas equation can be derived as follows:
According to Boyle's law

$$V \propto \frac{1}{P} \quad \text{...(i)}$$

According to Charles' law

$$V \propto T \quad \text{...(ii)}$$

Combining Boyle's law (i) and Charles' law (ii), we get

$$V \propto \frac{1}{P} \times T$$

$$V \propto \frac{T}{P}$$

$$V = K\frac{T}{P}$$

$$\frac{PV}{T} = K \text{ (where } K \text{ is constant)}$$

Hence, Perfect Gas Equation is

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

where P_1 = Initial pressure,

P_2 = Final pressure,

V_1 = Initial volume,

V_2 = Final volume,

T_1 = Initial temperature,

T_2 = Final temperature.

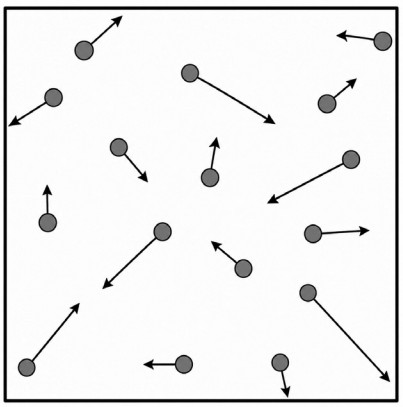
OBJECTIVE QUESTIONS

1. Based on the Periodic Table, how many elements are known to exist inherently as gases under normal pressure and temperature conditions?
(A) Seven elements
(B) Nine elements
(C) Eleven elements
(D) Thirteen elements

Ans : (C)

The Periodic Table explicitly contains only eleven chemical elements inherently known to exist completely in the natural gaseous state under standard normal atmospheric pressure and ambient temperature conditions. These unique elements predictably exhibit highly uniform and consistent macroscopic physical behaviour unconditionally.

2. The diagram shows molecules of a gas enclosed in a container. The arrows indicate the motion of the molecules. Which characteristic property of gases is best explained by the phenomenon depicted?



(A) High compressibility
(B) Low density
(C) Exertion of pressure
(D) High rate of diffusion

Ans : (C)

The diagram illustrates that gas molecules are in constant, random motion. Their frequent collisions with the walls of the container result in a continuous force exerted on the walls. This force per unit area is defined as the pressure of the gas. The other properties are not directly depicted by these collisions.

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(B) It occupies space and has mass
(C) It has no colour
(D) It cannot be touched

Ans :(B)

Matter is anything that occupies space and has mass. Air fills containers, exerts pressure, and has measurable mass, proving that it is a form of matter despite being invisible.

35. A fixed mass of gas undergoes a change in conditions as shown in the table. Calculate the final volume, V_2.

State	Pressure (P)	Volume (V)	Temperature (T)
Initial	1.0 atm	4.0 L	300 K
Final	2.0 atm	V_2	360 K

(A) 2.4 L
(B) 4.8 L
(C) 6.7 L
(D) 9.6 L

Ans :(A)

The combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, is used to solve this problem. Rearranging for V_2, we get $V_2 = (P_1V_1T_2)/(P_2T_1)$. Substituting the values from the table: $V_2 = (1.0 \text{ atm} \times 4.0 \text{ L} \times 360 \text{ K}) / (2.0 \text{ atm} \times 300 \text{ K})$. This simplifies to $V_2 = 1440 / 600 = 2.4$ L.

36. A student pushes the plunger of a syringe filled with water and another filled with air. Which can be compressed more easily?
(A) Water
(B) Both equally
(C) Air
(D) Neither

Ans :(C)

Air is a gas and contains large intermolecular spaces. Water is a liquid with much smaller spaces between particles. Therefore, air can be compressed far more easily than water.

37. Which of the following temperatures is the highest?
(A) 273 K
(B) 0°C
(C) 100 K
(D) 50°C

Ans :(D)

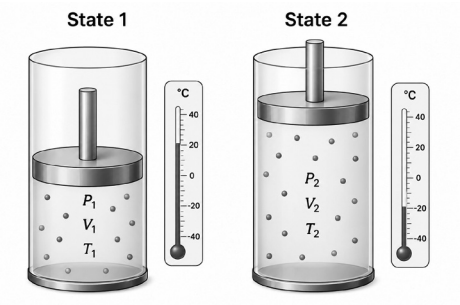
Converting to Kelvin: 50°C = 323 K, while 0°C = 273 K. Therefore, 50°C is the highest temperature among the given options.

38. A gas occupies the entire room because its particles:
(A) Have fixed positions
(B) Are closely packed
(C) Move randomly in all directions
(D) Have maximum attraction

Ans :(C)

Gas particles are in continuous random motion. They spread throughout all available space, which is why gases expand to fill the entire volume of a room or container.

39. A fixed mass of gas in a cylinder with a movable piston undergoes a change from State 1 to State 2, where pressure, volume, and temperature all change. Which equation correctly describes the relationship between the two states?



(A) $P_1V_1 = P_2V_2$
(B) $V_1/T_1 = V_2/T_2$
(C) $P_1/T_1 = P_2/T_2$
(D) $P_1V_1/T_1 = P_2V_2/T_2$

Ans : (D)

When the pressure, volume, and temperature of a fixed mass of gas all change, the relationship between the initial (State 1) and final (State 2) conditions is described by the combined gas law. This law integrates Boyle's Law and Charles's Law into a single expression, which is correctly stated as $P_1V_1/T_1 = P_2V_2/T_2$.

40. Which of the following correctly represents standard pressure?
(A) 76 mm Hg
(B) 760 cm Hg
(C) 760 mm Hg
(D) 7.6 mm Hg

Ans :(C)

Standard atmospheric pressure is equal to 760 mm Hg, 76 cm Hg, or 1 atmosphere. These values are commonly used as reference conditions in gas law calculations.

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and occupy much greater volume compared to their mass. Therefore, gases have maximum intermolecular space and the lowest density among the three states of matter.

29. The following data were obtained for a fixed mass of gas at a constant temperature.

Trial	Pressure (P) in atm	Volume (V) in L
1	1.0	8.0
2	2.0	4.0
3	4.0	2.0
4	8.0	1.0

What conclusion can be drawn from the experimental data?

(A) The volume of the gas is directly proportional to its pressure.
(B) The volume of the gas is inversely proportional to its pressure.
(C) The sum of pressure and volume is always constant.
(D) The ratio of volume to pressure is always constant.

Ans :(B)

The data demonstrates Boyle's Law. As the pressure is doubled from 1.0 atm to 2.0 atm, the volume is halved from 8.0 L to 4.0 L. This inverse relationship ($P \propto 1/V$) holds true for all data points, as the product of pressure and volume ($P \times V$) is consistently 8.0 L-atm.

30. A gas is kept at constant temperature. If its volume becomes one-third, the pressure will:

(A) Become one-third
(B) Remain unchanged
(C) Become three times
(D) Become six times

Ans :(C)

Boyle's law states that pressure is inversely proportional to volume. If volume decreases to one-third, pressure must increase three times to keep the product PV constant.

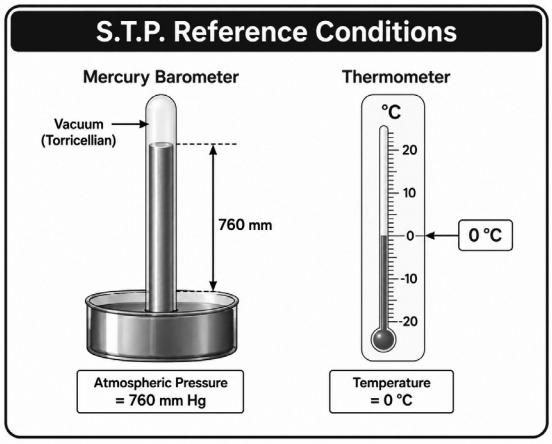
31. Which state of matter has particles that can slide past one another but remain fairly close together?

(A) Solid
(B) Liquid
(C) Gas
(D) Plasma

Ans :(B)

In liquids, particles are loosely packed and can move around each other. This allows liquids to flow while still maintaining a definite volume.

32. The diagram displays a set of standard reference values used in gas law calculations. What do these conditions, known as S.T.P., represent?



(A) The conditions at which all gases liquefy.
(B) The universal constants for any gas reaction.
(C) A standard set of temperature and pressure for comparing gas volumes.
(D) The minimum temperature and pressure a gas can withstand.

Ans :(C)

S.T.P. stands for Standard Temperature and Pressure. As the volume of a gas is highly dependent on both temperature and pressure, these standard conditions (0°C or 273 K and 1 atm or 760 mm Hg) are defined as a universal reference point. This allows for the fair comparison of gas volumes measured under different experimental conditions.

33. A gas sample is heated while its volume is kept constant. Which quantity is most likely to increase?

(A) Pressure
(B) Volume
(C) Mass
(D) Density decreases

Ans :(A)

When a gas is heated, its particles move faster. If volume is not allowed to increase, the particles collide more frequently with the container walls, causing pressure to rise.

34. Which observation best proves that air is matter?

(A) It is invisible

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compact arrangement also contributes to their generally higher density compared to liquids and gases.

47. Why are gases highly compressible?
(A) Strong intermolecular forces
(B) Small volume
(C) Large intermolecular spaces
(D) Fixed shape

Ans :(C)

Explanation: Gas molecules are separated by large distances. When pressure is applied, these spaces decrease and the molecules come closer together. Therefore, gases can be compressed much more easily than solids and liquids. This property is used in storing gases such as LPG and CNG in cylinders under high pressure.

48. Which state of matter has the minimum density?
(A) Solid
(B) Liquid
(C) Gas
(D) Ice

Ans :(C)

Explanation: Density depends on mass per unit volume. Gas particles are widely separated, occupying a large volume relative to their mass. Therefore, gases have much lower density than solids and liquids. This is why balloons filled with lighter gases can rise in air and why gases spread rapidly in open spaces.

49. Diffusion is maximum in:
(A) Solids
(B) Liquids
(C) Gases
(D) Crystals

Ans :(C)

Explanation: Diffusion is the spontaneous mixing of particles. Since gas molecules move rapidly and have maximum intermolecular spaces, they diffuse very quickly. For example, the smell of perfume spreads throughout a room within a short time. Diffusion occurs in solids and liquids too, but at a much slower rate.

50. Boyle's Law is applicable at:
(A) Constant pressure
(B) Constant temperature
(C) Constant volume
(D) Constant density

Ans :(B)

Explanation: Boyle's Law states that for a fixed mass of gas, volume is inversely proportional to pressure, provided temperature remains constant. If pressure increases, volume decreases and vice versa. This relationship is represented by PV = constant. The law is valid only when temperature does not change during the process.

51. According to Boyle's Law, if pressure becomes three times, volume becomes:
(A) Three times
(B) Half
(C) One-third
(D) Unchanged

Ans :(C)

Explanation: Boyle's Law states that pressure and volume are inversely proportional. Therefore, if pressure becomes three times its original value, the volume decreases to one-third. This relationship helps explain the operation of pumps, syringes and breathing mechanisms in living organisms.

52. Charles' Law relates:
(A) Pressure and volume
(B) Pressure and temperature
(C) Volume and temperature
(D) Density and pressure

Ans :(C)

Explanation: Charles' Law states that at constant pressure, the volume of a gas is directly proportional to its absolute temperature. As temperature increases, the kinetic energy of molecules increases, causing expansion. Therefore, heated gases occupy more space than colder gases under the same pressure conditions.

53. The SI unit of temperature used in gas laws is:
(A) °C
(B) °F
(C) Kelvin
(D) Rankine

Ans :(C)

Explanation: Gas law calculations require temperature to be measured on the absolute scale known as Kelvin. This scale begins at absolute zero and avoids negative temperature values. The conversion formula is K = °C + 273. Scientists use Kelvin because gas behaviour depends on absolute temperature rather than Celsius temperature.

54. 27°C is equal to:
(A) 246 K
(B) 273 K
(C) 300 K
(D) 373 K

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(iv) Gases easily under go diffusion.
(v) Solids and liquids have higher density compared to gases.
(vi) Gases have neither definite shape nor definite volume.

Ans :

(i) In the case of gases, the molecules are far apart from each other, therefore, the intermolecular space is maximum thus, gases can be compressed.
(ii) As on higher altitudes or in hilly areas, the pressure decreases. So, the boiling point of the liquid decreases, therefore, pressure cooker is used for cooking of food.
(iii) The molecules of gases move randomly in all possible directions, thus exerting pressure as pressure is defined as force acting per unit area. Hence pressure of a gas or its impact can be recorded on the walls of container per unit area.
(iv) It is so because gases have maximum intermolecular space.
(v) In case of solids, the molecules are closely packed. In the case of liquids, the molecules are loosely packed, whereas in gases, the molecules are far apart from each other. Thus, it is observed that the molecules per unit volume decrease and hence the density also decreases.
(vi) In the case of gases, the intermolecular space is maximum and intermolecular force of attraction is minimum or negligible. Hence the molecules do not experience any kind of attraction, therefore, they neither have definite shape nor definite volume.

THREE MARKS QUESTIONS

131. A student inflates a balloon and keeps it in a refrigerator. After an hour, the balloon appears smaller. Explain the observation with reference to the behaviour of gas particles.

Ans :

(i) Cooling decreases the kinetic energy of gas particles.
(ii) Gas particles move more slowly.
(iii) The volume of the gas decreases, causing the balloon to shrink.

132. Two identical syringes contain equal volumes of air. One piston is pushed inward while the other is left untouched. What difference will be observed and why?

Ans :

(i) The volume of air decreases in the pushed syringe.
(ii) Air particles come closer due to pressure.
(iii) This demonstrates the compressibility of gases.

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133. A student opens a bottle of perfume at one end of a classroom. Within minutes, the smell reaches the last bench. What conclusion can be drawn about the nature of gases?

Ans :

(i) Gas molecules are in continuous random motion.
(ii) They diffuse from regions of higher concentration to lower concentration.
(iii) Therefore, the smell spreads throughout the room.

134. A weather balloon released from the ground becomes much larger at higher altitudes. Explain this observation.

Ans :

(i) Atmospheric pressure decreases with height.
(ii) The gas inside experiences less external pressure.
(iii) Therefore, the gas expands and the balloon becomes larger.

135. A student writes 25°C as the temperature while solving a Charles' law problem. Identify the mistake and explain its significance.

Ans :

(i) Charles' law requires temperature in Kelvin.
(ii) 25°C should be converted to 298 K.
(iii) Using Celsius gives incorrect results.

136. A gas cylinder carries a warning: "Do not expose to direct sunlight." Explain the reason.

Ans :

(i) Heating increases the temperature of the gas.
(ii) Gas particles move faster and exert greater pressure.
(iii) Excess pressure may be dangerous.

to expand, diffuse and compress easily. It is one of the most important characteristics of gases.

63. Standard temperature is:
(A) 0°C
(B) 25°C
(C) 100°C
(D) -273°C

Ans :(A)

Explanation: Standard temperature is defined as 0°C or 273 K. Together with standard pressure (1 atm), it forms the standard conditions commonly used in gas law calculations and scientific measurements.

64. Which law combines Boyle's and Charles' laws?
(A) Avogadro's Law
(B) Graham's Law
(C) Perfect Gas Equation
(D) Dalton's Law

Ans :(C)

Explanation: The Perfect Gas Equation is derived by combining Boyle's Law and Charles' Law. It relates pressure, volume and temperature simultaneously and is useful when more than one variable changes during a gas process.

65. One millilitre is equal to:
(A) 10 cm^3
(B) 1 cm^3
(C) 100 cm^3
(D) 1000 cm^3

Ans :(B)

Explanation: The units millilitre and cubic centimetre are numerically equal. Therefore, 1 mL = 1 cm^3. This relationship is widely used in laboratory experiments and volumetric measurements.

66. Which property helps gases form homogeneous mixtures easily?
(A) High density
(B) Fixed volume
(C) Diffusion
(D) Rigidity

Ans :(C)

Explanation: Diffusion allows gas molecules to mix rapidly because of their continuous random motion and large intermolecular spaces. As a result, gases combine uniformly to form homogeneous mixtures without stirring.

67. Which of the following is NOT a property of gases?
(A) Highly compressible
(B) Definite shape
(C) Diffuse easily
(D) Low density

Ans :(B)

Explanation: Gases have neither definite shape nor definite volume. They take the shape and volume of their container because their particles move freely and experience negligible intermolecular attraction. High compressibility, diffusion and low density are characteristic properties of gases.

ONE MARK QUESTIONS

68. Why does a gas completely fill the vessel in which it is kept?

Ans :

Due to negligible intermolecular forces and continuous random motion of molecules.

69. State one property of gases that enables LPG to be stored in cylinders.

Ans :

High compressibility.

70. Why are solids almost incompressible?

Ans :

Their particles are closely packed with very little intermolecular space.

71. Name the state of matter that possesses a definite volume but no definite shape.

Ans :

Liquid.

72. Which state of matter has the weakest intermolecular forces?

Ans :

Gas.

73. Why do gases diffuse much faster than liquids?

Ans :

Because gas particles have large intermolecular spaces and move freely.

74. Which temperature scale is used while applying gas laws? Give a reason.

Ans :

Kelvin scale; it is based on absolute temperature.

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75. 8. A gas occupies 500 cm^3 at a certain pressure. What happens to its volume if the pressure is increased at constant temperature?

Ans :

The volume decreases.

76. Name the law which explains the relationship between pressure and volume at constant temperature.

Ans :

Boyle's law.

77. Name the law which explains the relationship between volume and absolute temperature at constant pressure.

Ans :

Charles' law.

78. Why is the Kelvin scale called the absolute scale of temperature?

Ans :

Its zero corresponds to absolute zero.

79. What is the significance of absolute zero temperature?

Ans :

It is the lowest possible temperature at which volume becomes theoretically zero.

80. State one characteristic that distinguishes liquids from gases.

Ans :

Liquids have a definite volume whereas gases do not.

81. Why is the density of gases much lower than that of solids?

Ans :

Gas particles are far apart from one another.

82. Convert 25°C into Kelvin.

Ans :

298 K.

83. A gas is heated at constant pressure. State the effect on its volume.

Ans :

Its volume increases.

84. Name the quantity that remains constant in Boyle's law.

Ans :

Temperature.

85. Name the quantity that remains constant in Charles' law.

Ans :

Pressure.

86. Why is atmospheric pressure commonly expressed in mm of Hg?

Ans :

It is measured using a mercury barometer.

87. State one observation that proves gases exert pressure.

Ans :

(A) inflated balloon remains stretched due to the pressure of the gas inside.

88. Account how temperature and molecular motion are inter-related?

Ans :

(A) the temperature increases the molecules gain K.E. (kinetic energy) and start moving faster.

89. Convert: (i) 285 °C in kelvin (ii) 365 K in °C.

Ans :

(i) $285 + 273 = 558$ K
(ii) $365 - 273 = 92$ °C.

90. Discuss the relationship between kelvin and Celsius scales of temperature ?

Ans :

K = °C + 273.

91. What is S.T.P. or N.T.P. and what are its values?

Ans :

It is the standard or normal condition of temperature and pressure.

Temperature = 273 K

Pressure = 760 mm Hg or 76 cm Hg.

92. Define the behaviour of gases in terms of molecular motion?

Ans :

The molecules of gases are far apart from each other, therefore, the intermolecular force of attraction is minimum or negligible. Hence the molecules move in all possible directions.

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93. Why pressure and temperature should be given while providing the volume of a gas ?

Ans :

Volume is inversely related to pressure and directly related to absolute temperature.

94. Why Kelvin temperature is always positive?

Ans :

(A) the lowest temperature is zero degree kelvin.

95. Define diffusion.

Ans :

Intermixing of gases to form homogeneous mixture is called diffusion.

96. Explain why absolute zero is a theoretical concept?

Ans :

(A) it is the last or the lowest limit of the temperature at which the molecular motion ceases or stop which is practically not possible. Hence it is a theoretical value.

97. Name the quantity which is constant in
(i) Boyle's law
(ii) Charles' law.

Ans :

(i) Temperature
(ii) Pressure

98. Match the following:

	Column I		**Column II**
(i)	Boyle's law	(a)	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
(ii)	Charles' law	(b)	$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
(iii)	Perfect gas equation	(c)	$P_1 V_1 = P_2 V_2$

(i) (c)
(ii) (a)
(iii) (b)

99. Fill in the blanks.
(i) 1 Atmosphere = _____cm Hg = ___mm Hg.
(ii) 1 litre = _____ mL = _____ cm3.
(iii) Normal temperature −273 K = _____°C.
(iv) Gases have _____ density.
(v) Gases have neither definite _____ nor definite _____.

Ans :

(i) 76, 760
(ii) 1000, 1000
(iii) 0
(iv) minimum
(v) shape, volume

TWO MARKS QUESTIONS

100. A syringe containing air is sealed at the nozzle and pushed inward. What change occurs in the air inside? Name the property of gases illustrated.

Ans :

(i) The volume of air inside the syringe decreases.
(ii) This shows that gases are highly compressible due to large intermolecular spaces.

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101. A student sprays perfume in one corner of a room. After some time, its smell is detected throughout the room. Explain.

Ans :

(i) Gas particles are in continuous random motion.
(ii) They mix with air by diffusion and spread throughout the room.

102. A balloon kept in sunlight becomes larger after some time. Explain the observation.

Ans :

(i) The temperature of the gas inside the balloon increases.
(ii) According to Charles' law, the volume of a gas increases with increase in temperature.

103. Why can LPG be stored in cylinders?

Ans :

(i) Gases are highly compressible.
(ii) A large volume of gas can be compressed and stored in a small cylinder under pressure.

104. Why are solids almost incompressible?

Ans :

(i) The particles in solids are very closely packed.
(ii) There is very little intermolecular space between the particles.

150. A student heats a gas at constant pressure and records an increase in volume. Which law supports this observation? Explain.

Ans :

(i) Charles' law supports the observation.
(ii) Volume is directly proportional to absolute temperature.
(iii) Therefore, volume increases on heating.

FOUR MARKS QUESTIONS

151. A student carried out an experiment on a fixed mass of gas and obtained the following observations:

Pressure (atm)	Volume (cm^3)
1	400
2	200
4	100

(a) State the relationship between pressure and volume.
(b) Name the law verified by the data.
(c) Which physical quantity was kept constant during the experiment?
(d) Predict the volume of the gas at 8 atm pressure.

Ans :

(a) Pressure is inversely proportional to volume.
(b) Boyle's law.
(c) Temperature.
(d) 50 cm^3.

152. A weather balloon is released from the Earth's surface. As it rises higher in the atmosphere, it becomes larger.
(a) Why does the balloon expand?
(b) What happens to atmospheric pressure with increase in altitude?
(c) What happens to the volume of the gas inside the balloon?
(d) Name the property of gases responsible for this behaviour.

Ans :

(a) The external pressure decreases.
(b) Atmospheric pressure decreases.
(c) The volume of the gas increases.
(d) Compressibility of gases.

153. Riya placed an inflated balloon inside a freezer. After some time, she noticed that the balloon had shrunk.
(a) What happens to the kinetic energy of gas molecules?
(b) What happens to the volume of the gas?
(c) Which gas law explains this observation?
(d) What will happen when the balloon is brought back to room temperature?

Ans :

(a) The kinetic energy decreases.
(b) The volume decreases.
(c) Charles' law.
(d) The balloon regains its original size.

154. Study the following observations:
- Perfume smell spreads throughout a room.
- LPG is stored in cylinders.
- Air fills every corner of a room.
- A football becomes harder when kept in sunlight.

Identify the property of gases illustrated in each case.

Ans :

- Diffusion.
- Compressibility.
- No definite shape and volume.
- Expansion on heating.

155. A student used 25°C directly while solving a Charles' law problem and obtained an incorrect answer.
(a) Why is the calculation incorrect?
(b) What is the temperature in Kelvin?
(c) Which temperature scale should be used in gas laws?
(d) Why is this scale preferred?

Ans :

(a) Charles' law requires temperature in Kelvin.
(b) 298 K.
(c) Kelvin scale.
(d) It is the absolute temperature scale.

156. The following readings were obtained during an experiment:

Temperature (K)	Volume (cm^3)
300	200
600	400

(a) What happens to the volume when temperature doubles?

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Ans :

(i) 173 K (ii) 546 K
(iii) 293 K (iv) 278 K
(v) 283 K

121. State Boyle's law. What happens when pressure in doubled?

Ans :

(A) constant temperature, pressure of a gas is inversely proportional

$$P \propto \frac{1}{V} \quad \text{(At constant } T\text{)}$$

or $$P = K.\frac{1}{V}$$

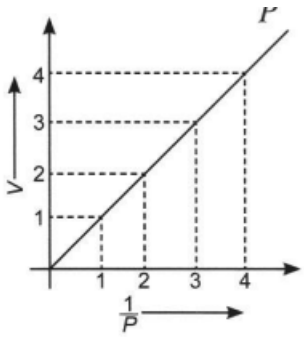
$$PV = K$$

When pressure is doubled, then volume becomes half.

122. Plot a graph showing the verification of Boyle's law.

Ans :

Boyle's law can be verified by plotting graph of V vs. $\frac{1}{P}$.



123. Convert the following in Celsius:

(a) 287 K (b) 33 K
(c) 185 K (d) 368 K

Ans :

(a) $287 - 273 = 14°C$

(b) $33 - 273 = -240°C$

(c) $185 - 273 = -88°C$

(d) $368 - 273 = 95°C$

124. State absolute zero.

Ans :

It is a theoretical value. It is the last or the lowest limit of temperature at which the molecular motion ceases or stops. The temperature for absolute zero is -273 °C.

125. Why does the size of a weather balloon become larger and larger as it ascends into higher space?

Ans :

(A) higher altitude, the pressure reduces due to which expansion in gas molecules inside the balloon increases. Hence the balloon becomes larger in size.

126. Kelvin scale has been majorly adopted for the chemical calculation. Why?

Ans :

It is because it starts with $-273°C$ as its zero and magnitude of each degree on Kelvin scale is same as on centigrade scale. Besides, all temperatures on Kelvin scale are positive.

127. Write the importance of STP.

Ans :

In order to compare the masses and densities of the gases, their temperature and pressure are taken at STP or NTP because volume of a given mass of gas depends upon temperature and pressure.

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128. Match the following:

	Column I (Temperature in Celsius)	**Column II (Temperature in Kelvin)**
(i)	0 °C	546 K
(ii)	273 °C	293 K
(iii)	-273 °C	290 K
(iv)	20 °C	0 K
(v)	17 °C	273 K

Ans :

(i) (e) (ii) (a) (iii) (d)
(iv) (b) (v) (c)

Level 2

129. Write the value of standard pressure in
(i) atm, (ii) mm Hg, (iii) cm Hg

Ans :

(i) 1 atm
(ii) 760 mm Hg
(iii) 76

130. State your answer.

(i) Gases are highly compressible.
(ii) Pressure cookers are widely used in hilly areas.
(iii) Pressure is exerted by gas in all direction.

Ans :(C)

Explanation: To convert Celsius into Kelvin, add 273 to the Celsius temperature. Therefore, 27 + 273 = 300 K. Such conversions are essential while applying Charles' Law and the Perfect Gas Equation because temperatures must always be expressed in Kelvin.

55. One litre equals:
(A) 10 cm^3
(B) 100 cm^3
(C) 1000 cm^3
(D) 10000 cm^3

Ans :(C)

Explanation: Volume is commonly measured in litres, millilitres and cubic centimetres. One litre is equal to 1000 millilitres and also equal to 1000 cubic centimetres. These unit conversions are frequently used while solving numerical problems based on gas laws.

56. Standard atmospheric pressure is:
(A) 100 mm Hg
(B) 500 mm Hg
(C) 760 mm Hg
(D) 1000 mm Hg

Ans :(C)

Explanation: Standard pressure is defined as 1 atmosphere. This is equal to 760 mm of mercury or 76 cm of mercury. Standard pressure is used as a reference condition in gas law calculations and laboratory measurements.

57. Absolute zero temperature is:
(A) 0°C
(B) -100°C
(C) -273°C
(D) 273°C

Ans :(C)

Explanation: Absolute zero is the lowest theoretically possible temperature. At this temperature, the volume of an ideal gas becomes zero and molecular motion reaches its minimum possible value. On the Kelvin scale, absolute zero corresponds to 0 K.

58. Which equation represents Boyle's Law?
(A) PV = Constant
(B) V/T = Constant
(C) P/T = Constant
(D) PT = Constant

Ans :(A)

Explanation: Boyle's Law shows an inverse relationship between pressure and volume. When temperature remains constant, the product of pressure and volume remains unchanged. This equation is useful in understanding compression and expansion of gases.

59. Which equation represents Charles' Law?
(A) PV = Constant
(B) V/T = Constant
(C) P/T = Constant
(D) VT = Constant

Ans :(B)

Explanation: Charles' Law states that volume is directly proportional to absolute temperature at constant pressure. Therefore, the ratio of volume to temperature remains constant for a fixed mass of gas. This explains why heated balloons expand.

60. Which state of matter flows freely in all directions?
(A) Solid
(B) Liquid
(C) Gas
(D) Crystal

Ans :(C)

Explanation: Gas molecules move randomly and independently due to negligible intermolecular forces. Therefore, gases spread and flow freely in all directions. Liquids can flow but mainly under gravity, whereas gases fill the entire available space.

61. The intermolecular force of attraction is maximum in:
(A) Gas
(B) Liquid
(C) Solid
(D) Vapour

Ans :(C)

Explanation: Solid particles are held together by very strong intermolecular forces. These forces keep particles closely packed and prevent free movement. Consequently, solids have fixed shapes and are difficult to compress.

62. Which state has maximum intermolecular space?
(A) Solid
(B) Liquid
(C) Gas
(D) Ice

Ans :(C)

Explanation: Gas molecules are separated by very large distances compared to solids and liquids. This maximum intermolecular space allows gases

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137. During an experiment, the pressure on a gas is doubled while keeping the temperature constant. Predict the effect on volume.

Ans :

(i) Volume decreases.
(ii) Pressure and volume are inversely related.
(iii) This follows Boyle's law.

138. Why is it easier to compress air than water? Explain using particle arrangement.

Ans :

(i) Air particles have large intermolecular spaces.
(ii) Water particles are comparatively closer together.
(iii) Therefore, air is more compressible than water.

139. A football kept in the sun becomes harder. Explain the observation.

Ans :

(i) Air inside the football gets heated.
(ii) The kinetic energy of particles increases.
(iii) The pressure inside the football increases.

140. A student claims that gases have no mass because they cannot be seen. Do you agree? Give reasons.

Ans :

(i) No, the statement is incorrect.
(ii) Gases occupy space.
(iii) Gases have mass and therefore are matter.

141. A balloon filled with hydrogen bursts when overinflated. Explain this using the kinetic theory of gases.

Ans :

(i) More gas particles are added into the balloon.
(ii) Collisions with the walls increase.
(iii) Excess pressure causes the balloon to burst.

142. Why are gas molecules able to move freely whereas solid particles cannot?

Ans :

(i) Gas molecules are far apart.
(ii) Intermolecular forces are negligible.
(iii) Therefore, gases move freely in all directions.

143. An aerosol can should not be thrown into fire. Explain.

Ans :

(i) Heating increases the temperature of the gas inside.
(ii) Pressure inside the can increases.
(iii) The can may explode.

144. A diver notices that an air bubble released underwater becomes larger as it rises. Explain.

Ans :

(i) Water pressure decreases near the surface.
(ii) The gas experiences less pressure.
(iii) Hence, the volume of the bubble increases.

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145. Why is Kelvin called the absolute scale of temperature?

Ans :

(i) It starts from absolute zero.
(ii) Negative temperatures are not possible on this scale.
(iii) It is used in gas law calculations.

146. A student observes that ink spreads slowly in water but perfume spreads quickly in air. What can be inferred?

Ans :

(i) Diffusion occurs in both liquids and gases.
(ii) Gas particles move faster than liquid particles.
(iii) Hence diffusion is faster in gases.

147. Explain why gases do not have a fixed shape.

Ans :

(i) Gas particles are not fixed in position.
(ii) They move freely in all directions.
(iii) Therefore, gases take the shape of the container.

148. Why are solids generally denser than gases?

Ans :

(i) Solid particles are closely packed.
(ii) They occupy less space for the same mass.
(iii) Therefore, solids have greater density.

149. A gas occupies the entire container while a liquid does not. Explain.

Ans :

(i) Gas particles move freely in all directions.
(ii) Liquids have stronger intermolecular forces than gases.
(iii) Therefore, gases fill the entire container.

105. A gas occupies 500 cm^3 at a certain pressure. The pressure is increased while temperature remains constant. Predict the change.

Ans :

(i) The volume of the gas decreases.
(ii) This is in accordance with Boyle's law.

106. Why is Kelvin scale used in gas law calculations?

Ans :

(i) Gas laws are based on absolute temperature.
(ii) Kelvin is the absolute temperature scale.

107. Why do gases have the lowest density among the three states of matter?

Ans :

(i) Gas molecules are far apart from each other.
(ii) They occupy a large volume for a given mass.

108. Why do gases exert pressure on the walls of a container?

Ans :

(i) Gas molecules are in continuous random motion.
(ii) Their collisions with the walls exert pressure.

109. Why do gases diffuse more rapidly than liquids?

Ans :

(i) Gas molecules possess high kinetic energy.
(ii) They have large intermolecular spaces.

110. A football left in the sun becomes tighter. Explain.

Ans :

(i) The air inside gets heated.
(ii) The increased temperature causes the gas to expand and exert greater pressure.

111. Why do gases have neither definite shape nor definite volume?

Ans :

(i) Gas molecules move freely in all directions.
(ii) They occupy the entire available space of the container.

112. Explain why liquids have a definite volume but no definite shape.

Ans :

(i) Liquid particles are closely packed, giving a definite volume.
(ii) They can move past one another and take the shape of the container.

113. What is the significance of absolute zero?

Ans :

(i) It is the lowest possible temperature.
(ii) At this temperature, the volume of a gas becomes theoretically zero.

114. A gas is cooled at constant pressure. What happens to its volume?

Ans :

(i) The volume decreases.
(ii) According to Charles' law, volume is directly proportional to absolute temperature.

115. Why is diffusion faster in gases than in solids?

Ans :

(i) Gas particles move freely and rapidly.
(ii) Solids have closely packed particles with negligible movement.

116. Why does a weather balloon expand as it rises higher in the atmosphere?

Ans :

(i) Atmospheric pressure decreases with altitude.
(ii) The gas inside expands and occupies a larger volume.

117. State two observations that show gases are matter.

Ans :

(i) Gases occupy space.
(ii) Gases have mass and exert pressure.

118. Why can gases flow in all directions?

Ans :

(i) Gas molecules are not fixed in position.
(ii) They move freely due to negligible intermolecular forces.

119. Explain why gases are easily compressed whereas liquids are not.

Ans :

(i) Gases have large intermolecular spaces.
(ii) Liquids have comparatively smaller intermolecular spaces.

120. Convert the following temperature (in °C) to the Kelvin temperature.

(i) -100 °C (ii) 273 °C (iii) 20 °C
(iv) 5 °C (v) 10 °C

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(b) Name the law illustrated.
(c) Which quantity remains constant?
(d) Predict the volume at 900 K.

Ans :

(a) The volume doubles.
(b) Charles' law.
(c) Pressure.
(d) 600 cm^3.

157. A diver releases an air bubble underwater. The bubble becomes larger as it rises towards the surface.
(a) Why does the bubble expand?
(b) What happens to the external pressure?
(c) Which law explains the observation?
(d) State the relationship between pressure and volume.

Ans :

(a) External pressure decreases.
(b) It decreases.
(c) Boyle's law.
(d) Pressure is inversely proportional to volume.

158. A gas cylinder carries the warning: "Do not expose to direct sunlight."
(a) What happens to the gas molecules on heating?
(b) What happens to the pressure inside the cylinder?
(c) Why can this be dangerous?
(d) Which property of gases is involved?

Ans :

(a) They move faster.
(b) Pressure increases.
(c) The cylinder may burst.
(d) Expansion of gases on heating.

159. A student claims that liquids and gases have identical properties because both do not have a fixed shape.
State four differences to prove that the statement is incorrect.

Ans :

- Liquids have definite volume; gases do not.
- Liquids are slightly compressible; gases are highly compressible.
- Liquid particles are closer together; gas particles are far apart.
- Diffusion is slower in liquids than in gases.

160. An aerosol spray is used in a classroom.
(a) What state of matter spreads through the room?
(b) Which property allows it to spread rapidly?
(c) Why is spreading faster in air than in water?
(d) Name the process involved.

Ans :

(a) Gas.
(b) Diffusion.
(c) Gas particles move faster and have larger intermolecular spaces.
(d) Diffusion.

161. A student pumps air into a bicycle tyre. After some time, the tyre becomes firm.
(a) What happens to the air inside the tyre?
(b) Which property of gases is involved?
(c) What happens to the intermolecular space?
(d) Why does the tyre become firm?

Ans :

(a) The air gets compressed.
(b) Compressibility of gases.
(c) The intermolecular space decreases.
(d) Increased air pressure makes the tyre firm.

162. A sealed plastic bottle partially filled with air is taken to a hill station. The bottle appears swollen.
(a) What change occurs in atmospheric pressure at higher altitudes?
(b) What happens to the air inside the bottle?
(c) Why does the bottle swell?
(d) Which gas law supports this observation?

Ans :

(a) Atmospheric pressure decreases.
(b) The air expands.
(c) The volume increases due to lower external pressure.
(d) Boyle's law.

163. A student observes that a drop of perfume spreads much faster in air than a drop of ink spreads in water.
(a) Name the process involved.
(b) In which medium is diffusion faster?
(c) Give one reason for this difference.
(d) What does this indicate about the arrangement of particles in gases?

Ans :

(a) Diffusion.
(b) Air.

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$$P_2 = \frac{750 \times 600}{500}$$
$$= 900 \text{ mm Hg.}$$

177. A gas occupies 400 cm^3 under 760 mm Hg pressure. Find under what pressure the gas will occupy 380 cm^3, the temperature remains constant.

Ans :

Given, $P_1 = 760$mm Hg,
$V_1 = 400 \text{ cm}^3$,
$P_2 = ?$,
$V_2 = 380 \text{ cm}^3$,

Using Byoyle's law,

$$P_1 V_1 = P_2 V_2$$
$$P_2 = \frac{760 \times 400}{380}$$
$$= 800 \text{ mm Hg.}$$

The required pressure is 800 mm Hg or 80 cm Hg.

178. At constant temperature a gas occupies a volume of 2000 cm^3 at a pressure of 740 mm of mercury. Find at what pressure its volume will be 500 cm^3.

Ans :

Initial volume of the gas, $V_1 = 2000 \text{ cm}^3$

Initial pressure of the gas, $P_1 = 740$ mm Hg

Final volume of the gas, $V_2 = 500 \text{ cm}^3$

Final pressure of the gas, $P_2 = ?$

According to Boyle's law,

$$P_1 V_1 = P_2 V_2$$
$$740 \times 2000 = P_2 \times 500$$
$$P_2 = \frac{2000 \times 740}{500}$$
$$= 2960 \text{ mm Hg.}$$

179. A gas occupies the initial volume of 400 cm^3 at a pressure Z. If the pressure is changed to 5 atmosphere, the volume of the gas was found to be 200 cm^3. Calculate the value of Z.

Ans :

Given,

$P_1 = Z$,
$P_2 = 5$atm,
$V_1 = 400 \text{ cm}^3$,
$V_2 = 200 \text{ cm}^3$

Using Boyle's law,

$$P_1 V_1 = P_2 V_2$$
$$Z \times 400 = 5 \times 200$$
$$Z = \frac{5 \times 200}{400}$$
$$= 2.5 \text{ atm}$$

180. Calculate the pressure of 2.5 litre of dry hydrogen gas, if it occupies a volume of 3 litres at 1.2 atmosphere. Assume that the temperature remains constant.

Ans :

Here,

$P_1 = ?$,
$V_1 = 2.5$ litres,
$P_2 = 1.2$ atm,
$V_2 = 3.0$ litres

Now, $P_1 V_1 = P_2 V_2$

$$P_1 \times 2.5 = 1.2 \times 3.0$$
$$P_1 = \frac{1.2 \times 3.0}{2.5}$$
$$= 1.44 \text{ atm}$$

181. At constant temperature, a gas is at a pressure of 540 mm of mercury. At what pressure its volume decreases by 60%.

Ans :

Let the initial volume of gas

$$(V_1) = x$$
$$60\% \text{ of initial volume} = \frac{60}{100}x = 0.6\,x$$

The final volume of gas $(V_2) = x - 0.6x = 0.4\,x$

The initial pressure of gas

$$(P_1) = 540 \text{ mm Hg}$$

Final pressure of gas $(P_2) = ?$

$$P_1 V_1 = P_2 V_2$$
$$P_2 = \frac{P_1 V_1}{V_2} = \frac{540 \times x}{0.4\,x}$$
$$= 1350 \text{ mm Hg}$$

182. The volume of certain gas was found 400 cm^3, when pressure was 520 mm of Hg. If the pressure is increased by 30%, find the new volume of the gas.

Ans :

Initial volume of gas, $V_1 = 400 \text{ cm}^3$

Initial pressure of gas, $P_1 = 520$ mm Hg

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NUMERICAL QUESTIONS

171. A 226 mL of oxygen gas is heated from 18.5 °C to 96 °C at constant pressure. Calculate the new volume of oxygen.

Ans :

Given,

$$V_1 = 226 \text{ mL},$$
$$V_2 = ?$$
$$T_1 = 18.5 + 273$$
$$= 291.5\text{K},$$
$$T_2 = 96 + 273$$
$$= 369 \text{ K}.$$

Now, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$$= \frac{226}{291.5}$$
$$= \frac{V_2}{369}$$
$$V_2 = \frac{226 \times 369}{291.5}$$
$$= \frac{83394}{291.5} = 286.09 \text{ mL}.$$

172. Gas 'A occupies 55 mL at 91 °C and 6 atm. What will be the volume of the gas 'A at S.T.P.?

Ans :

Given,

$$P_1 = 6 \text{ atm},$$
$$P_2 = 1 \text{ atm},$$
$$V_1 = 55 \text{ mL},$$
$$V_2 = ?$$
$$T_1 = 91 + 273 = 364 \text{ K}$$
$$T_2 = 273 \text{ K}$$

Now, $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$$\frac{6 \times 55}{364} = \frac{1 \times V_2}{273}$$
$$V_2 = \frac{6 \times 55 \times 273}{364}$$
$$= \frac{90090}{364} \text{ mL}$$

173. $V_2 = 247.5$ mL. The volume of a sample of gas is 12.5 mL at a pressure of 38 cm Hg. At what pressure will the volume be 7.5 mL, keeping temperature constant?

Ans :

$$V_1 = 12.5 \text{ mL},$$
$$V_2 = 7.5 \text{ mL},$$
$$P_1 = 38 \text{ cm Hg},$$
$$P_2 = ?$$
$$P_1 V_1 = P_2 V_2$$
$$12.5 \times 38 = P_2 \times 7.5$$
$$P_2 = \frac{12.5 \times 38}{7.5}$$
$$= 63.33 \text{ cm Hg}.$$

174. 7. Convert the following temperature to kelvin.

(i) 15 °C (ii) −200 °C
(iii) 40 °C (iv) 25 °C
(v) 173 °C

Ans :

(i) $15 + 273 = 288$ K

(ii) $-200 + 273 = 73$ K

(iii) $40 + 273 = 313$ K

(iv) $25 + 273 = 298$ K

(v) $173 + 273 = 446$ K

175. 8. Convert the following temperature to Celsius.

(i) 486 K (ii) 209 K
(iii) 590 K (iv) 789 K
(v) 150 K

Ans :

(i) $486 - 273 = 213°C$

(ii) $209 - 273 = -64°C$

(iii) $590 - 273 = 317°C$

(iv) $789 - 273 = 516°C$

(v) $150 - 273 = -123°C$

176. What will be the pressure required to reduce 600 mL of a dry gas at 750 mm pressure to 500 mL at the same temperature.

Ans :

Given,

$$P_1 = 750 \text{ mm Hg},$$
$$V_1 = 600 \text{ mL},$$
$$P_2 = ?,$$
$$V_2 = 500 \text{ mL}$$
$$P_1 V_1 = P_2 V_2$$
$$750 \times 600 = P_2 \times 500$$

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Ans :

Given, $P_1 = 740\text{mm Hg},$

$P_2 = 760 \text{ mm Hg},$

$V_1 = 2.5 \text{ cm}^3,$

$V_2 = ?,$

$T_1 = 27 + 273\text{K},$

$K = 300$

$T_2 = 273\text{K}$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{740 \times 2.5}{300} = \frac{760 \times V_2}{273}$$

$$V_2 = \frac{740 \times 2.5 \times 273}{760 \times 700}$$

$$V_2 = \frac{505050}{228000}$$

$$= 2.215 \text{ cm}^3.$$

188. 6 dm^3 of a dry gas at temperature of 27 °C has pressure of 700 mm Hg. Find the volume of gas at S.T.P.

Ans :

Given, $P_1 = 700\text{mm Hg},$

$P_2 = 760 \text{ mm Hg},$

$V_1 = 6 \text{ dm}^3,$

$V_2 = ?,$

$T_1 = 27 + 273\text{K},$

$K = 300 \text{ K},$

$T_2 = 273\text{K}$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{700 \times 6}{300} = \frac{760 \times V_2}{273}$$

$$V_2 = \frac{700 \times 6 \times 273}{300 \times 760}$$

$$= \frac{1146600}{228000} = 5.03 \text{ cm}^3.$$

189. Moist nitrogen at a pressure of 700 mm Hg and temperature 27°C is found to occupy a volume of 100 cm^3. Find the volume of dry nitrogen gas at S.T.P. (Aqueous tension at 27°C is 15 mm Hg)

Ans :

Given, $P_1 = 700 - 15$

$= 685\text{mm Hg},$

$P_2 = 760 \text{ mm Hg},$

$V_1 = 100 \text{ cm}^3,$

$V_2 = ?,$

$T_1 = 27 + 273$

$= 300 \text{ K},$

$T_2 = 273 \text{ K}$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{685 \times 100 \times 273}{300 \times 760} = \frac{760 \times V_2}{273}$$

$$V_2 = \frac{700 \times 6 \times 273}{300 \times 760}$$

$$= \frac{187005}{2280}$$

$$= 82.01 \text{ cm}^3.$$

190. Calculate the pressure of a gas, when its volume is 250 mL initially, the gas is expanded to volume of 1000 mL and the pressure of 0.4 atmosphere. The temperature during the reaction remains constant.

Ans :

Here,

$P_1 = ?,$

$V_1 = 250\text{mL},$

$P_2 = 0.4\text{atm},$

$V_2 = 1000\text{mL}$

$P_1 V_1 = P_2 V_2$

$P1 \times 250 = 0.4 \times 1000$

$$P_1 = \frac{0.4 \times 1000}{250}$$

$$= 1.6\text{atm}$$

191. At a constant temperature, a gas at a pressure of 750 mm of mercury occupies a volume of 1000 cm^3. If volume is decreased by 40%, find the new pressure.

Ans :

Given,

$P_1 = 750 \text{ mm Hg},$

$P_2 = ? \text{ atm},$

$V_1 = 1000 \text{ cm}^3$

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$$\text{30\% of initial pressure} = 520 \times \frac{30}{100}$$
$$= 156 \text{ mm Hg}$$
$$\text{Final pressure, } P_2 = 156 + 520$$
$$= 676 \text{ mm Hg}$$
$$\text{Final volume of gas, } V_2 = ?$$
$$\text{Now, } P_1 V_1 = P_2 V_2$$
$$520 \times 400 = 676 \times V_2$$
$$V_2 = \frac{520 \times 400}{676}$$
$$= 307.69 \text{ cm}^3$$

183. The volume occupied by a certain gas was found 5.6 dm^3 when the pressure was 2 atmosphere. If the pressure is increased by 20%, find the new volume of the gas.

Ans :

$$\text{Initial volume of gas, } V_1 = 5.6 \text{ dm}^3$$
$$\text{Initial pressure of gas, } P_1 = 2 \text{ atm}$$
$$\text{20\% of initial pressure} = 2 \times \frac{20}{100}$$
$$= \frac{4}{10} = 0.4$$
$$\text{Final pressure, } P_2 = 0.4 + 2$$
$$= 2.4 \text{ atm}$$
$$\text{Final volume, } V_2 = ?$$
$$P_1 V_1 = P_2 V_2$$
$$2 \times 5.6 = 2.4 \times V_2$$
$$V_2 = \frac{5.6 \times 2}{676}$$
$$= 307.69 \text{ cm}^3$$

184. 100 cm^3 of a gas at 27 °C is cooled to 20 °C at constant pressure. Calculate the volume of gas at 20 °C.

Ans :

$$\text{Initial volume } (V_1) = 100 \text{ cm}^3$$
$$\text{Initial temperature } (T_1) = 27 + 273$$
$$= 300 \text{ K}$$
$$\text{Final volume } (V_2) = ?$$
$$\text{Final temperature } (T_2) = 20 + 273$$
$$= 293 \text{ K}$$
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$= \frac{100}{300} = \frac{V_2}{293}$$
$$V_2 = \frac{100 \times 293}{300}$$
$$= 97.67 \text{ cm}^3$$

185. Hydrogen gas occupies a volume of 400 cm^3 at a temperature of 27 °C and normal atmospheric pressure. Find the volume of the gas at 10 °C at constant pressure.

Ans :

$$\text{Initial volume } (V_1) = 400 \text{ cm}^3$$
$$\text{Initial temperature } (T_1) = 27 + 273$$
$$= 300 \text{ K}$$
$$\text{Final volume } (V_2) = ?$$
$$\text{Final temperature } (T_2) = 10 + 273$$
$$= 283 \text{ K}$$
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$= \frac{400}{300} = \frac{V_2}{283}$$
$$V_2 = \frac{400 \times 283}{300}$$
$$= 377.33 \text{ cm}^3$$

186. Carbon dioxide occupies a volume of 336 cm^3 at S.T.P. Find its volume at 20 °C and at a pressure of 700 mm Hg.

Ans :

$$\text{Given, } P_1 = 760 \text{ mm Hg},$$
$$P_2 = 700 \text{ mm Hg},$$
$$V_1 = 336 \text{ cm}^3,$$
$$V_2 = ?,$$
$$T_1 = 273\text{K},$$
$$T_2 = 20 + 273$$
$$= 293 \text{ K}$$

According to Perfect Gas equation

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$
$$\frac{760 \times 336}{273} = \frac{700 \times V_2}{293}$$
$$V_2 = \frac{760 \times 336 \times 293}{273 \times 700}$$
$$V_2 = \frac{74820480}{191100}$$
$$= 391.525 \text{ cm}^3.$$

187. 2.5 dm^3 of dry nitrogen gas is collected at a temperature of 27 °C and a pressure of 740 mm Hg. Find the volume of gas at S.T.P.

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CASE BASED QUEATIONS

197. Rahul is studying the microscopic model of gases in his chemistry class and focuses on the kinetic molecular theory. He learns about a given mass of gas molecules enclosed within a sealed container of volume ten litres. He continuously notes that the constituent molecules are moving rapidly and randomly in all possible directions. He wonders about the actual space occupied by the molecules themselves and the forces acting between them under these ordinary room conditions. He also theorizes what would happen to the molecular energy if the room temperature was artificially manipulated.

(a) State two assumptions of the kinetic molecular theory regarding the volume of molecules and the forces of attraction between them.

(b) State what happens to the average kinetic energy of these enclosed gas molecules if the absolute temperature of the gas is doubled.

(c) Name the specific scientific term used to describe the theoretical temperature at which all molecular motion of these gas particles completely ceases.

Ans :

(a) 1. The total volume of the actual molecules of a gas is considered entirely negligible when compared to the vast total volume occupied by the gas.
2. Under ordinary atmospheric conditions of pressure and temperature, there exist absolutely no intermolecular forces of attraction or repulsion between the moving gas molecules.

(b) If the absolute temperature of the gas is doubled, the average kinetic energy of the moving gas molecules will also get exactly doubled because they are directly proportional.

(c) The theoretical temperature at which all molecular motion completely ceases is called absolute zero, which is mathematically equal to zero Kelvin or minus 273 degrees Celsius.

198. Varun is preparing for a meteorological school project and decides to research the mechanics of a large hot air balloon. He hypothetically pumps a fixed mass of dry atmospheric air into the balloon at an initial temperature of twenty degrees Celsius. He understands that for meteorological applications, hot air is specifically inflated into balloons because of a fundamental gas law. He notes that when the balloon is left in the bright sun, the trapped air inside expands rapidly. He worries it might burst if the volume increases beyond the fabric's physical capacity.

(a) State Charles' law, which mathematically explains the relationship between the volume and temperature of a gas under these specific conditions.

(b) Calculate the absolute temperature of the air inside the balloon when it is initially heated to twenty degrees Celsius.

(c) State what happens to the physical density of the trapped gas inside the balloon as the internal temperature continuously rises in the sun.

Ans :

(a) 1. Charles' law states that the volume of a given mass of a dry gas increases or decreases by 1/273 of its volume at zero degrees Celsius.
2. This volumetric change occurs for each one degree Celsius increase or decrease in temperature respectively, provided the pressure remains completely constant.

(b) Formula: $K = {}^{\circ}C + 273$

Substitution: $K = 20 + 273$

Result: 293K

(c) As the temperature of the gas rises, the volume expands proportionately, which causes the overall physical density of the enclosed gas to significantly drop or decrease.

199. Sneha plans to travel to a high-altitude mountain region in the Himalayas for a trekking expedition. She is learning about the physical behaviour of gases and notes that atmospheric pressure drops significantly at such higher altitudes. Her chemistry teacher explains that this massive pressure drop directly affects the density of the air and the availability of oxygen for breathing. She is strongly advised to carry a portable oxygen cylinder to avoid altitude sickness. She reviews her textbook to understand the inverse relationship governing this phenomenon.

(a) Explain the direct relationship between the pressure and density of a gas at a constant temperature based on Boyle's law.

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$$40\%\text{ of nitial volume} = \frac{40}{100} \times 1000 = 400\ \text{cm}^3$$

$$V_2 = 1000 - 400 = 600\ \text{cm}^3$$

$$P_1 V_1 = P_2 V_2$$

$$750 \times 1000 = P_2 \times 600$$

$$P_2 = \frac{750 \times 1000}{600}$$

$$= 1250\ \text{mm Hg}$$

192. A gas is enclosed in a vessel at standard temperature. At what temperature, the volume of enclosed gas will be 1/6 of its initial volume, given that the pressure remains constant.

Ans :

Let the initial volume of gas $(V_1) = x$

Initial temperature of gas

$$(T_1) = 0^\circ C$$

$$= 0 + 273\text{K}$$

$$= 273\text{K}$$

Final volume $(V_2) = \frac{x}{6}$

Final temperature $(T_2) = ?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{x}{273} = \frac{x}{6 \times T_2}$$

$$T_2 = \frac{273x}{6 \times x}$$

$$= 45.5\text{K}$$

$$T_2 = 45.5 - 273$$

$$= -227.5^\circ\text{C}.$$

193. A sample of a gas has a volume of 160 mL at a pressure of 864 mm Hg at a certain temperature. What will be the volume if the pressure is changed to 1440 mm Hg keeping temperature constant?

Given,

$$V_1 = 160\ \text{mL},$$

$$V_2 = ?,$$

$$P_1 = 864\ \text{mm Hg},$$

$$P_2 = 1440\ \text{mm Hg},$$

$$P_1 V_1 = P_2 V_2$$

$$160 \times 864 = V_2 \times 1440$$

$$V_2 = \frac{160 \times 864}{1440}$$

$$= 96\ \text{mL}.$$

194. Convert the following temperature on the Kelvin Scale to the Celsius Scale.

(i) 150 K (ii) 335 K

(iii) 250 K (iv) 100 K

(v) 446 K

Ans :

$^\circ\text{C} = \text{K} - 273$

(i) $150 - 273 = -123^\circ\text{C}$

(ii) $335 - 273 = 62^\circ\text{C}$

(iii) $250 - 273 = -23^\circ\text{C}$

(iv) $100 - 273 = -173^\circ\text{C}$

(v) $446 - 273 = 173^\circ\text{C}$

195. Convert the following in kelvin:

(i) 25 °C (ii) 95 °C

(iii) 218 °C (iv) −102 °C

Ans :

(a) $25 + 273 = 298\,\text{K}$

(b) $95 + 273 = 368\,\text{K}$

(c) $218 + 273 = 491\,\text{K}$

(d) $-102 + 273 = 171\,\text{K}$

196. The pressure of a gas at S.T.P. is tripled when temperature is raised to 546 °C. What will be the change in volume?

Ans :

Given,

$$P_1 = 760\ \text{mm Hg},$$

$$P_2 = 3 \times 760\ \text{mm Hg},$$

$$T_1 = 273\ \text{K},$$

$$T_2 = 546 + 273 = 819\ \text{K}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{760 \times V_1}{273} = \frac{3 \times 760 \times V_2}{819}$$

$$760 \times 819 \times V_1 = 3 \times 760 \times 273 \times V_2$$

$$\frac{V_1}{V_2} = \frac{3 \times 760 \times 273}{760 \times 819}$$

$$= 1$$

$$V_1 = V_2$$

Therefore, the volume remains the same.

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202. Rohit is tasked with measuring the absolute temperatures of different chemical liquid baths in the school laboratory. He is provided with a standard glass thermometer that reads exclusively in the Celsius scale. He accurately records the freezing point of a special solution at minus fifteen degrees Celsius and another boiling chemical solution at one hundred and twenty degrees Celsius. His teacher then asks him to systematically convert these recorded readings into a scientific temperature scale that has absolutely no negative values, originally designed by Lord Kelvin.

(a) Write the simple mathematical relationship used for directly converting temperature from the Celsius scale to the Kelvin scale.

(b) Calculate the absolute temperature of the freezing solution on the Kelvin scale.

(c) Calculate the absolute temperature of the boiling chemical solution on the Kelvin scale.

(d) State the exact numerical value of the temperature on the Celsius scale that directly corresponds to zero Kelvin.

Ans :

(a) The simple mathematical relationship used for converting temperature from one scale to another is represented by the formula:

$$K = {}^{\circ}C + 273.$$

(b) Formula: $K = {}^{\circ}C + 273$

Substitution: $K = -15 + 273$

Result: $258K$

(c) Formula: $K = {}^{\circ}C + 273$

Substitution: $K = 120 + 273$

Result: $393K$

(d) The exact numerical value of the temperature on the Celsius scale that directly corresponds to absolute zero or zero Kelvin is minus 273 degrees Celsius.

203. Arjun is studying the mathematical pressure and volume relationship in real gases. He performs a physical experiment using a medical syringe apparatus equipped with a sealed nozzle. He adjusts the internal compression by placing identically massed objects on top of the moving apparatus and records the gradual changes in the physical volume of the trapped air.

(a) Describe what happens to the movable part and the enclosed air volume when the circular weights are removed one by one, keeping the temperature constant.

(b) Write the mathematical equation for the specific gas law demonstrated by this setup when a fixed mass of dry gas is compressed at a constant temperature.

(c) State the exact relationship between the physical volume and pressure of a dry gas at a constant temperature as verified by this verified experiment.

Ans :

(a) 1. When the circular weights are removed one by one, the applied pressure continuously decreases, which causes the movable piston to move upwards.

2. As the movable piston shifts upwards, the enclosed space expands, thereby significantly increasing the total volume of the trapped air.

(b) The mathematical equation for Boyle's law demonstrated by this experimental setup is $P_1V_1 = P_2V_2 = k$, where k is a constant.

(c) The relationship states that the physical volume of a given mass of a dry gas is inversely proportional to its pressure at a completely constant temperature.

204. Meera is generating pure nitrogen gas in the laboratory and collecting it using a specific displacement method over a pool of liquid. She observes large bubbles rising quickly through the fluid inside the collection vessel. She knows from

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(b) Describe how Boyle's law is explained purely on the basis of the kinetic molecular theory of gases when the volume of a gas decreases.

Ans :

(a) 1. According to Boyle's law, as the pressure on a fixed mass of gas increases, its volume proportionally reduces at a constant temperature.
2. Because the same mass is now confined in a smaller volume, the density of the gas increases, making density directly proportional to the pressure.

(b) 1. When a gas is compressed into a smaller volume, the widely spaced molecules are pushed closer together, giving them much less space to move around freely.
2. Therefore, these moving molecules hit the rigid walls of the container much more frequently, which results in the exertion of an increased physical pressure.

200. Kavya is performing stoichiometric calculations in her laboratory notebook for a physical chemistry exercise involving hydrogen gas. The dry hydrogen gas initially occupies a measured volume of 1000 millilitres at a temperature of 546 Kelvin and a pressure of 380 millimetres of mercury. She needs to calculate what the exact volume of this gas would be if it were subjected to standard laboratory conditions. To achieve this, she carefully applies the combined gas equation. Her teacher reminds her to cross-check the standard atmospheric values before substituting the numbers into her final formula.

(a) State the exact numerical values of standard temperature in Kelvin and standard pressure in atmospheres as commonly used in these gas law calculations.

(b) Calculate the final volume of the hydrogen gas at standard temperature and pressure using the combined gas equation.

Ans :

(a) 1. The standard temperature chosen for reference in gas law calculations is exactly zero degrees Celsius, which is equal to 273 Kelvin.
2. The standard pressure chosen for reference in gas law calculations is exactly one atmospheric unit (1 atm), which is equal to 760 millimetres of mercury.

(b) Formula: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Substitution: $\frac{380 \times 1000}{546} = \frac{760 \times V_2}{273}$

Result: $V_2 = 250\text{mL}$

201. Anjali conducts various small physical experiments with gases in her school chemistry laboratory. She takes a highly compressed portable cylinder of nitrogen gas and opens the metallic valve slightly in a large enclosed room. Within a few minutes, her classmates standing far away can physically detect the spread of the gas across the entire room. She also observes that the cylinder, which feels relatively light compared to a solid iron block of the exact same size, can successfully store a massive amount of nitrogen under extreme high pressure.

(a) Name the characteristic property of gases that allows the nitrogen molecules to mix gradually with the surrounding air in the laboratory.

(b) State the primary reason why gases exhibit a very low density when compared to heavy solid and liquid states of matter.

(c) State what happens to the inter-molecular distance when this nitrogen gas rapidly expands from a region of high pressure to a region of low pressure.

(d) Name the specific state of matter where constituent particles are completely free to randomly move about in the entire available space.

Ans :

(a) The characteristic property that allows the gradual mixing of two substances kept in contact by molecular motion is called diffusion.

(b) Gases have low density because the weak inter-molecular forces of attraction result in very large inter-molecular distances, greatly increasing the total occupied volume.

(c) When a gas rapidly expands from a region of high pressure to a region of low pressure, the inter-molecular distance between the gas molecules increases significantly.

(d) The state of matter in which inter-particle attraction is very weak and particles are completely free to randomly move is known as the gaseous state.

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(c) Gas particles move more freely.
(d) Gas particles are far apart.

164. A gas occupies 300 cm^3 at a certain temperature. It is heated while keeping the pressure constant.
(a) What happens to the volume?
(b) Which law explains this change?
(c) What happens to the kinetic energy of the molecules?
(d) State the relationship between temperature and volume.

Ans :
(a) The volume increases.
(b) Charles' law.
(c) It increases.
(d) Volume is directly proportional to temperature.

165. A student compares a brick, water and air kept in separate containers.
(a) Which has a definite shape?
(b) Which has a definite volume but no definite shape?
(c) Which has neither definite shape nor definite volume?
(d) Which has the maximum intermolecular space?

Ans :
(a) Brick.
(b) Water.
(c) Air.
(d) Air.

166. During an experiment, a gas at 273 K occupies 250 cm^3. It is heated to 546 K at constant pressure.
(a) What happens to the temperature?
(b) What happens to the volume?
(c) Name the law involved.
(d) Calculate the final volume.

Ans :
(a) Temperature doubles.
(b) Volume doubles.
(c) Charles' law.
(d) 500 cm^3.

167. A student notices that an empty balloon weighs slightly less than the same balloon filled with air.
(a) What does this prove about air?
(b) Is air a form of matter?
(c) Give one reason for your answer.
(d) State one other property of matter shown by air.

Ans :
(a) Air has mass.
(b) Yes.
(c) It has mass and occupies space.
(d) It occupies space.

168. Two identical balloons are filled with equal amounts of air. One is placed in hot water and the other in cold water.
(a) Which balloon becomes larger?
(b) Why?
(c) Which gas law explains this?
(d) Which balloon has gas molecules with greater kinetic energy?

Ans :
(a) The balloon in hot water.
(b) The gas expands on heating.
(c) Charles' law.
(d) The balloon in hot water.

169. A scientist records the following data:

Pressure (atm)	**Volume (cm^3)**
2	300
3	200

(a) What relationship is observed?
(b) Name the law illustrated.
(c) What is the product PV in both cases?
(d) What does this indicate?

Ans :
(a) Inverse relationship.
(b) Boyle's law.
(c) 600.
(d) PV remains constant.

170. A gas cylinder is opened in a room. After some time, the gas spreads throughout the room.
(a) What process causes the spreading?
(b) Why do gas molecules spread in all directions?
(c) What type of motion do gas molecules possess?
(d) What kind of mixture is formed eventually?

Ans :
(a) Diffusion.
(b) They move freely.
(c) Continuous random motion.
(d) A homogeneous mixture.

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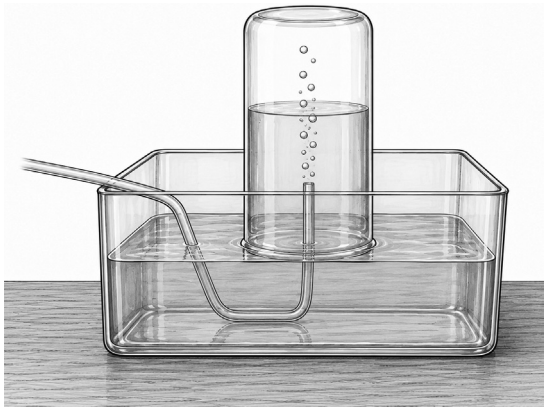
her textbook that the total pressure inside the sealed collection jar is not entirely due to the newly formed nitrogen gas alone, but includes an additional invisible factor released from the liquid pool used.



(a) Name the specific partial pressure term used to describe the pressure exerted by the liquid's vapour that mixes with the gas during this collection method.

(b) Write the mathematical formula used to calculate the actual pressure of the dry gas when it is collected over water in this specific manner.

(c) A total mass of twenty-four grams of oxygen gas is successfully enclosed in a one cubic decimetre flask at 25 degrees Celsius. Calculate the volume occupied by this mass of oxygen at Standard Temperature and Pressure, given that the molar mass of oxygen gas is 32 grams and one mole occupies 22.4 litres at Standard Temperature and Pressure.

Ans :

(a) The specific partial pressure exerted by the water vapour that mixes with the collected gas inside the vessel is commonly known as aqueous tension.

(b) The mathematical formula is: Actual pressure of dry gas is equal to the Total pressure minus the Aqueous tension.

(c) 1. Formula:

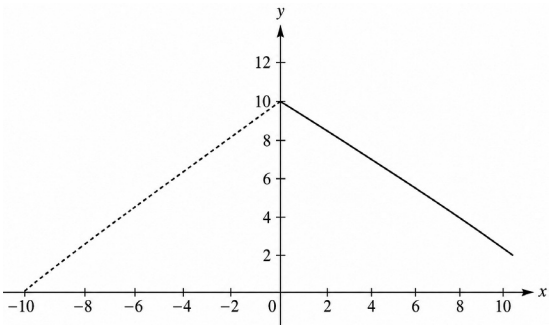
$$\text{Volume at STP} = \frac{\text{Given mass}}{\text{Molar mass}} \times \text{Standard molar volume}$$

2. Substitution:

$$\text{Volume} = \frac{24}{32} \times 22.4$$

Result: 16.8dm^3.

205. Siddharth is analyzing the graphical representation of Charles' law using experimental gas data provided by his teacher. He plots the total volume of a fixed mass of gas against its temperature in degrees Celsius at a strictly constant pressure. He immediately notices the straight plotted line does not start at the regular origin but intersects the horizontal axis at a specific negative mathematical value when logically extrapolated backwards.



(a) Identify the exact numerical temperature value where the dashed line intersects the horizontal axis, and state what this unique temperature point is called.

(b) Explain why the mathematical line is extended backwards as a dashed line rather than a solid line, and state what happens to the molecular motion at this theoretical point according to the kinetic model.

Ans :

(a) 1. The exact numerical temperature value where the backward dashed line intersects the horizontal axis is minus 273 degrees Celsius.

2. This specific mathematical intersection point on the temperature scale is scientifically known as absolute zero or zero Kelvin.

(b) 1. The line is drawn as a dashed line backwards because absolute zero is merely a theoretical concept, and actual gases will logically liquefy before reaching this extremely cold temperature.

2. According to the kinetic molecular theory, at this theoretical absolute zero temperature, the constant random molecular motion of all gas particles completely ceases.

206. Divya is thoroughly studying the unique isothermal behaviour of ideal gases in her physics lab. She plots the mathematical product of pressure and volume entirely against

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OBJECTIVE QUESTIONS

1. Which of the following statements correctly describe the components of the environment?

I. The atmosphere extends to a height of about 1600 km above the earth.

II. The hydrosphere covers exactly fifty percent of the surface of the earth.

III. The lithosphere is the solid component consisting of mountains, rocks, and soil.

IV. The biosphere includes the parts of other spheres where living organisms interact.

(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

Ans : (B)

The environment is comprised of four main spheres. The atmosphere extends approximately 1600 km high. The lithosphere contains solid materials like mountains and soil. The biosphere involves living organism interactions. However, the hydrosphere covers about seventy-five percent of the earth's surface.

2. Match the major components of the environment in List-I with their correct description in List-II.

List-I (Component)

P. Atmosphere

Q. Hydrosphere

R. Lithosphere

S. Biosphere

List-II (Description)

I. Consists of mountains, rocks, and soil

II. Region where living organisms interact

III. Gaseous cover extending above the earth

IV. Comprises oceans, seas, rivers, and lakes

(A) P-III, Q-IV, R-I, S-II
(B) P-III, Q-I, R-IV, S-II
(C) P-IV, Q-III, R-I, S-II
(D) P-II, Q-IV, R-I, S-III

Ans : (A)

The atmosphere provides the protective gaseous envelope surrounding the planet. The hydrosphere incorporates all major liquid water bodies. The lithosphere represents the solid crustal material forming mountains and soil. The biosphere is where living organisms actively interact with these surrounding spheres.

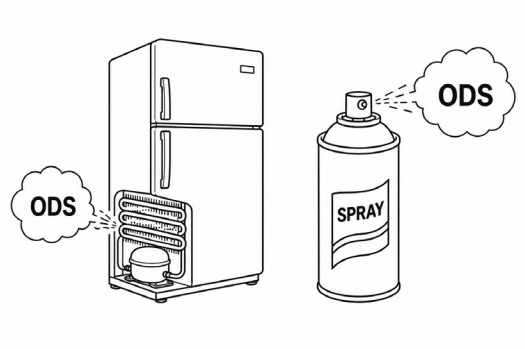
3. Which of the following gases are considered trace components in the earth's atmosphere?

(A) Nitrogen, oxygen, and water vapour
(B) Carbon dioxide and argon
(C) Oxides of sulphur, nitrogen, and hydrogen
(D) Methane, helium, and ammonia

Ans : (C)

Nitrogen, oxygen, and water vapour constitute the major components of the atmosphere. Carbon dioxide and argon serve as minor components. Meanwhile, oxides of sulphur and nitrogen, other noble gases, hydrogen, and ozone are present only as trace components in air.

4. The items shown in the diagram were common sources of chemicals that cause stratospheric ozone depletion. What is the general name for these ozone-depleting substances (ODS) used as refrigerants and propellants?



(A) Volatile organic compounds (VOCs)
(B) Chlorofluorocarbons (CFCs)
(C) Polycyclic aromatic hydrocarbons (PAHs)
(D) Perfluorocarbons (PFCs)

Ans : (B)

Chlorofluorocarbons (CFCs) are highly stable, non-toxic compounds that were widely used as refrigerants in refrigerators and air conditioners, and as propellants in aerosol cans. When released, they drift up to the stratosphere, where they are broken down by UV radiation to release chlorine atoms, which catalytically destroy the ozone layer.

5. Which of the following is an example of a natural source of air pollution?

(A) Burning of fossil fuels in factories
(B) Release of volcanic ash during an eruption
(C) Emission of carbon monoxide from vehicles
(D) Industrial runoff contaminating nearby rivers

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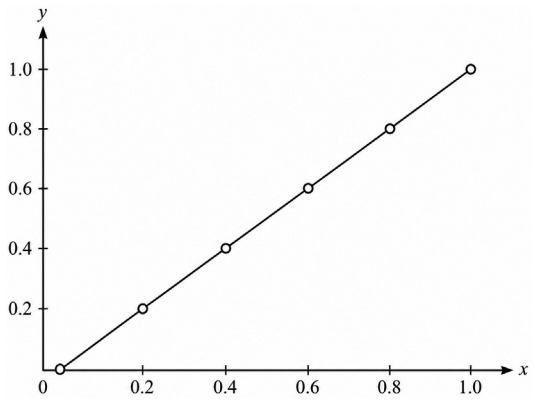
relationship existing between these two manipulated experimental variables.



(a) Identify the fundamental gas law that is experimentally verified by the straight diagonal line originating directly from the zero origin point.

(b) State the exact mathematical proportionality between the two specific physical variables plotted on the axes that results in this straight diagonal line.

(c) A fixed mass of gas occupies a certain volume at constant temperature. State what happens to the total volume of this dry gas if its physical pressure is forcibly decreased to exactly one-fourth of its original value.

(d) State the singular physical condition that must logically remain strictly constant for this graphical inverse relationship to hold perfectly true for a given mass of dry gas.

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Ans :

(a) The fundamental gas law that is experimentally verified by this straight diagonal line passing strictly through the origin is Boyle's law.

(b) The mathematical relationship physically demonstrated is that the pressure of the gas is directly proportional to the reciprocal of the volume.

(c) If the physical pressure is decreased to exactly one-fourth of its original value, the total volume of the dry gas will become exactly four times its original volume.

(d) For this specific graphical inverse relationship to hold perfectly true, the overall temperature of the given mass of dry gas must remain strictly constant.

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to made dirty in the context of environmental degradation.

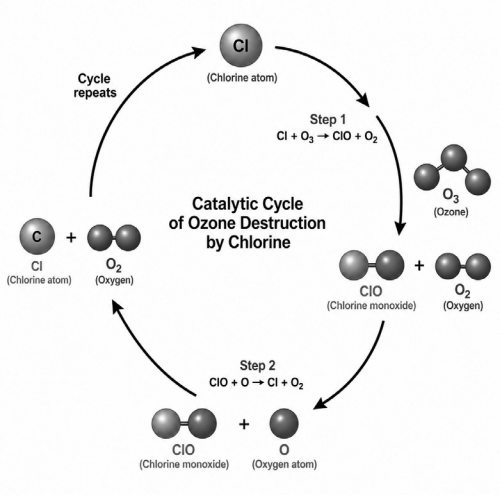
11. Smog is a harmful atmospheric pollutant that reduces visibility and induces respiratory diseases. Which of the following best describes the composition of smog?

(A) A mixture of carbon dioxide and water vapour
(B) A combination of oxides of nitrogen, sulphur, and partially-oxidised hydrocarbons
(C) A dense cloud of unburned carbon particles and pure ozone
(D) A suspension of volcanic ash and atmospheric methane

Ans : (B)

Smog represents a dangerous chemical pollutant usually produced by modern industries and automobiles. It constitutes a dark, thick combination involving oxides of nitrogen and sulphur alongside partially-oxidised hydrocarbons. This soot-laden fog significantly impairs visibility and easily triggers various respiratory ailments.

12. The diagram illustrates the catalytic cycle of ozone destruction. What is the significance of the chlorine atom (Cl) in this process?



(A) It is permanently converted to chlorine monoxide (ClO).
(B) It reacts once and then becomes inert.
(C) It acts as a catalyst, destroying many ozone molecules.
(D) It directly combines with oxygen atoms to form chlorine dioxide.

Ans : (C)

The chlorine atom acts as a catalyst in the destruction of ozone. It initiates a reaction that breaks down an ozone molecule but is regenerated at the end of the cycle, unchanged. This means a single chlorine atom can go on to destroy thousands of ozone molecules before it is eventually removed from the stratosphere.

13. Which pair of air pollutants and their respective health effects is correctly matched?

(A) Hydrogen sulphide – Destruction of vegetation and bones
(B) Fluorides – Affects teeth and bones
(C) Lead – Causes photochemical smog
(D) Cotton dust – Impairs metabolic activities

Ans : (B)

Different air pollutants trigger distinct biological consequences. Fluorides significantly harm surrounding vegetation while negatively affecting animal teeth and skeletal bones. In contrast, lead specifically impairs metabolic activities, hydrogen sulphide primarily irritates human eyes, and cotton dust exposure typically induces lung fibrosis.

14. **Assertion (A) :** Increased atmospheric concentrations of carbon monoxide can lead to coma and death.
Reason (R) : Carbon monoxide at concentrations greater than 750 ppm causes severe asphyxiation.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Carbon monoxide poses severe health hazards due to its strong affinity for haemoglobin. At moderate levels above 100 ppm, it creates breathing difficulties. When concentrations exceed 750 ppm, it induces deadly asphyxiation, depriving vital organs of oxygen, causing coma and death.

15. Smaller concentrations of nitrogen dioxide in the air specifically cause which of the following health issues?

(A) Inflammation of lung tissues resulting in pulmonary oedema
(B) Severe damage to the nervous system and brain
(C) Instantaneous death by rapid suffocation
(D) Extreme reduction of white blood cells leading to leukaemia

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(ii) Large quantities of NO_2 can lead to serious lung congestion and in some cases can prove fatal.
(iii) The presence of nitrogen dioxide severely damages the leaves of the plants.
(iv) Nitrogen dioxide in the presence of light oxidizes hydrocarbon leading to the formation of photochemical smog which cause irritation in eyes, asthma attack and other respiratory tract infections.

4.1 Effect of Acid Rain:

Acid rain has a very adverse affect on the soil chemistry, the water bodies, buildings and the vegetation:
(i) Acid rain removes the basic essential nutrients from the soil.
(ii) Acid rain increases the acidic character of the water bodies and thus the water becomes unfit for the survival of the aquatic animals like fishes.
(iii) Acid rain basically damages the leaves of the plants.
(iv) It has harmful effect on the sculptures monument and buildings made of limestone, marbles and metals.

Taj Mahal (one of the seven wonders of the world) made of marble which is chemically calcium carbonate is being eroded by the acid rain and if the emission of NO_2 and SO_2 are not stopped in the nearby refineries, then it can give a very ugly look to the Taj Mahal.

$$CaCO_3 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O + CO_2$$

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$$

5. GLOBAL WARMING

The rise in temperature of the earth's surface is called global warming. It is caused due to the trapping of sun's radiation by carbon dioxide in the atmosphere. This process is called greenhouse effect.

5.1 Greenhouse Gases

The gases which causes the greenhouse effect are called greenhouse gases. For example, carbon dioxide, methane, water vapour, ozone, chlorofluorocarbon, nitrous oxide etc.
The earth surface gets heated up by infrared radiations of the sunrays. Earth surface emits the infrared radiations and it escapes the earth's surface. During the process of emission some of the infrared rays get absorbed by the greenhouse gases and thus it remains on the earth and these trapped radiations warm the surface of the earth and lower atmosphere.

5.2 Effects of Global Warming:

The various effects of global warming are:
(i) It will lead to the melting of the glaciers and the polar ice caps which would lead to submerging of low lying coastal areas.
(ii) Global warming increases the water vapour in the atmosphere which will contribute further in increasing the temperature of the earth.

5.3 Ways of Reducing the Greenhouse Gases

Ways of Reducing the Greenhouse Gases in the Atmosphere:
(i) Afforestation: Plant more trees, save forests, increase green cover.
(ii) Minimum use of automobiles: Use more of public transport, car pools, ride bicycles for shorter distances, etc.
(iii) Burning of fossil fuels should be minimized.

6. FORMATION OF OZONE:

It is formed by the action of ultraviolet (UV) rays of the sun on oxygen.

$$3O_2(g) \xrightarrow{\text{UV rays}} 2O_3(g)$$

Ozone prevents the harmful ultraviolet radiations to reach the earth.
Ozone layer protects the life on the earth from harmful UV rays which would lead to several skin diseases.

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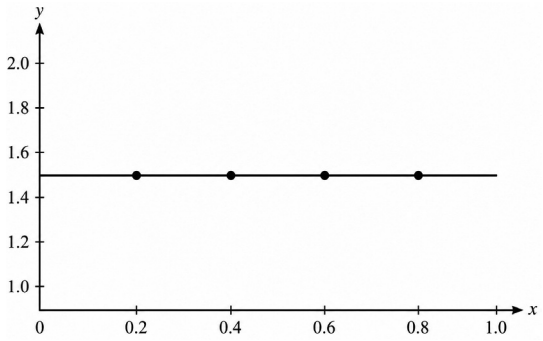
6.1 Depletion of Ozone Layer:

Decrease of the ozone in the stratosphere is called the depletion of the ozone layer or the destruction of the ozone layer.
The formation of the holes in the ozone layer causes the harmful UV rays to enter into the earth.

6.2 Causes of Depletion

The main causes of the depletion of ozone layer are:
(i) Excessive use of chlorofluorocarbons.
(ii) Flying of supersonic planes.

pressure for a fixed mass of gas at a completely constant temperature. She carefully observes the geometric shape of the resulting drawn curve and eagerly compares it to the fundamental gas law equations printed in her textbook.



(a) State the mathematical conclusion demonstrated by the straight horizontal line in this specific graph, and identify the fundamental gas law it visually verifies.

(b) Define the pressure of a gas in terms of mathematical force and physical area, and state the accepted Standard International (SI) unit used for measuring it.

Ans :

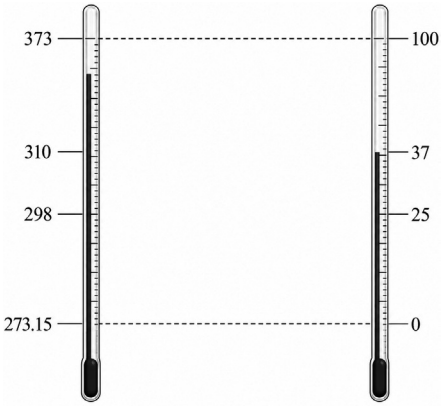
(a) 1. The perfectly straight horizontal line mathematically demonstrates that the product of pressure and volume remains entirely constant at a constant temperature.

2. This specific graphical representation physically verifies Boyle's law, showing that PV equals a constant value regardless of changing pressure.

(b) 1. The pressure exerted by a confined gas is precisely defined as the total force applied by the gas molecules to the vessel's wall per unit area.

2. The accepted Standard International unit for measuring this gas pressure is the pascal, which is equivalent to one newton per square metre.

207. Tarun is visually comparing two distinctly different temperature measurement scales printed in his chemistry textbook. He carefully looks at an illustration showing two identical glass liquid tubes, placed side by side. He notes the specific upper and lower fixed numerical points clearly marked on both tubes and strictly observes how the identical physical intervals are mathematically divided quite differently.



(a) Identify the specific scientific temperature scale represented by the measuring instrument drawn on the left side of the diagram.

(b) State the exact numerical value on the right-hand instrument that corresponds exactly to the two hundred and seventy-three point one five mark on the left.

(c) State the exact relationship between the average kinetic energy of moving gas molecules and the absolute temperature scale shown on the left instrument.

(d) Name the specific theoretical scientific term used to describe the absolute zero point on the temperature scale shown on the left instrument.

Ans :

(a) The specific scientific temperature measurement scale represented by the instrument on the left side of the diagram is the Kelvin scale.

(b) The exact numerical value on the right-hand Celsius instrument that directly corresponds to the two hundred and seventy-three point one five mark is zero degrees.

(c) According to the kinetic molecular theory, the average kinetic energy of gas molecules is directly proportional to the absolute temperature on the Kelvin scale.

(d) The specific theoretical scientific term used to describe the zero point on the Kelvin temperature scale is called absolute zero.

208. Nisha is mathematically plotting experimental data gathered from a gas compression laboratory exercise. She accurately creates a graph plotting the applied pressure purely against the reciprocal of the total volume. She carefully draws the straight line of best fit and actively uses it to successfully confirm the direct mathematical

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Ans : (B)

Pollutants originate from various natural and human activities. Natural disasters can rapidly elevate air pollution levels. For instance, when volcanoes erupt, they emit massive amounts of volcanic ash and harmful gases like sulphur dioxide, which severely degrade the surrounding air quality.

6. The table below shows the physiological effects of inhaling certain gaseous pollutants. Based on the information, which pollutant specifically impairs the oxygen-carrying capacity of blood?

Pollutant	**Primary Health Effect**
Sulphur Dioxide	Causes respiratory issues like bronchitis and irritates eyes.
Carbon Monoxide	Binds with haemoglobin, reducing oxygen supply to tissues.
Oxides of Nitrogen	Cause inflammation of lung tissues and respiratory problems.
Hydrogen Sulphide	Causes eye irritation and reduces crop growth.

(A) Sulphur Dioxide
(B) Carbon Monoxide
(C) Oxides of Nitrogen
(D) Hydrogen Sulphide

Ans : (B)

The table explicitly states that carbon monoxide binds with haemoglobin. This action forms carboxyhemoglobin, a stable compound that prevents haemoglobin from transporting oxygen effectively throughout the body. The other pollutants listed—sulphur dioxide, oxides of nitrogen, and hydrogen sulphide—cause irritation and damage to the respiratory system but do not directly interfere with blood's oxygen-carrying capacity.

7. Air pollution is caused by the presence of gaseous and particulate pollutants. Which of the following is considered a particulate pollutant?
(A) Sulphur dioxide
(B) Carbon monoxide
(C) Hydrocarbons
(D) Dust and smoke

Ans : (D)

Air pollution involves the harmful concentration of varied atmospheric contaminants. Gaseous pollutants typically include oxides of nitrogen, carbon, sulphur, and hydrocarbons. Conversely, particulate pollutants consist of minute solid particles and liquid droplets suspended in the air, such as dust and smoke.

8. Sulphur dioxide is a major gaseous pollutant. Which specific plant injury is directly caused by sulphur dioxide?
(A) Stem elongation
(B) Premature leaf fall
(C) Necrotic blotching
(D) Root nodule destruction

Ans : (C)

Sulphur dioxide exerts a severely damaging impact on various plant species. Upon significant exposure, it primarily affects the foliage, leading directly to specific leaf injuries. This characteristic physiological damage in plants is scientifically identified and commonly referred to as necrotic blotching.

9. Why is carbon monoxide considered extremely dangerous to human health?
(A) It causes acute irritation of the eyes and throat.
(B) It prevents haemoglobin from carrying oxygen to different parts of the body.
(C) It induces severe lung fibrosis and metabolic disorders.
(D) It directly inflames lung tissues causing pulmonary oedema.

Ans : (B)

Carbon monoxide is a highly toxic pollutant released mainly by incomplete fuel combustion. When inhaled, it aggressively binds with haemoglobin in the bloodstream. This effectively prevents the normal transport of vital oxygen to different biological tissues across the human body.

10. The word 'pollution' is derived from a Latin word 'pollutes'. What is the literal meaning of this word?
(A) To destroy completely
(B) Made dirty
(C) Harmful addition
(D) Toxic substance

Ans : (B)

Environmental pollution denotes the effect of undesirable changes in our surroundings that harm living organisms. The modern English term pollution is directly derived from the classical Latin word pollutes, which literally translates

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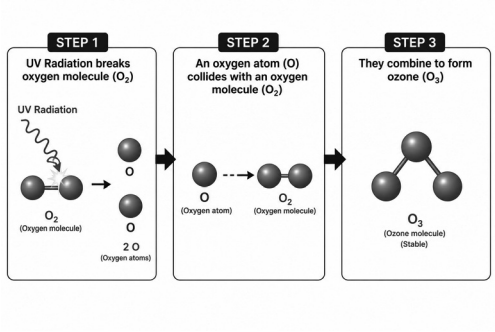
in the air?
(A) Hydrochloric acid (HCl)
(B) Carbonic acid (H_2CO_3)
(C) Nitric acid (HNO_3)
(D) Sulphuric acid (H_2SO_4)

Ans : (B)

Rainwater constantly interacts with naturally occurring atmospheric gases during precipitation. When water vapours condense and fall, airborne carbon dioxide seamlessly dissolves into the moisture. This specific interaction forms mild carbonic acid, which makes unpolluted normal rain naturally possess slightly acidic characteristics.

21. The diagram shows the natural process of ozone formation in the stratosphere. The dissociation of the O_2 molecule, shown in Step 1, is initiated by what form of solar energy?



(A) Ultraviolet radiation
(B) Infrared radiation
(C) Visible light
(D) Microwaves

Ans : (A)

High-energy ultraviolet (UV) radiation from the sun provides the energy required for the photolysis or photo-dissociation of diatomic oxygen (O_2). This process splits the molecule into two highly reactive oxygen atoms (O). Each of these atoms can then react with another oxygen molecule (O_2) to form an ozone molecule (O_3).

22. Rainwater is officially termed "acid rain" when its pH drops below normal levels. What is the usual pH range of acid rain?
(A) Between 7.0 and 6.5
(B) Between 6.5 and 5.6
(C) Between 5.6 and 3.5
(D) Between 3.5 and 1.5

Ans : (C)

Normal rainfall inherently displays a slightly acidic pH around 5.6. However, when rain heavily dissolves toxic gaseous oxides of sulphur and nitrogen, it forms strong mineral acids. This severe contamination drastically drops the usual pH range of acid rain between 5.6 and 3.5.

23. Which of the following is considered a principal natural phenomenon contributing to acid-producing gases in the atmosphere?
(A) Combustion of fossil fuels in industrial plants
(B) Emission of chlorofluorocarbons from refrigerators
(C) Combination of nitrogen and oxygen during lightning
(D) Excessive use of artificial agricultural fertilisers

Ans : (C)

While human activities predominantly drive modern acid rain, several natural phenomena also emit contributing gases. These natural sources importantly include intense volcanic activity, extensive forest fires, bacterial decomposition of organic matter, and atmospheric nitrogen combining with oxygen during powerful thunderstorm lightning strikes.

24. During the formation of sulphuric acid in the atmosphere, sulphur dioxide is first oxidised to which intermediate compound?
(A) Sulphur monoxide
(B) Hydrogen sulphide
(C) Sulphur trioxide
(D) Sulphurous acid

Ans : (C)

The industrial combustion of fossil fuels constantly releases massive amounts of sulphur dioxide. Within the atmosphere, this gaseous pollutant undergoes further oxidation to successfully form sulphur trioxide. Subsequently, this newly formed sulphur trioxide easily dissolves in atmospheric moisture to generate sulphuric acid.

25. Which of the following chemical reactions correctly represent the formation of acids contributing to acid rain?

I. $N_2(g) + O_2(g) \rightarrow 2NO(g)$
II. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
III. $4NO_2 + O_2 + 2H_2 \rightarrow O4HNO_3$
IV. $2SO_2 + O_2 \rightarrow SO_4$

(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV

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Ans : (A)

Oxides of nitrogen heavily impact overall human health. Exposure to smaller concentrations of nitrogen dioxide triggers harmful inflammation of sensitive lung tissues. This specific respiratory condition subsequently results in pulmonary oedema, while much higher concentrations usually cause bronchitis and associated problems.

16. A table from a science textbook is partially obscured. Identify the pollutant 'X' based on its described origin and health impact.

Pollutant	Origin	Health Impact
X	Produced due to incomplete burning of petrol, diesel, wood	Reduces oxygen in blood causing retardation and dizziness
Y	Produced by burning coal, oil, and natural gases	Reduces oxygen levels
Z	Released by refrigerators and air-conditioning systems	Reduces the ozone layer
W	Present in petrol, diesel, paints, and batteries	Damages the nervous and digestive systems

(A) X is Carbon dioxide
(B) X is Sulphur dioxide
(C) X is Carbon monoxide
(D) X is Suspended particulate matter

Ans : (C)

The table indicates that pollutant 'X' results from the incomplete combustion of fuels and leads to a reduction of oxygen in the blood, causing dizziness. This specific origin and health impact are characteristic of carbon monoxide (CO). Carbon dioxide is a product of complete combustion, while other pollutants have different primary sources and effects.

17. How does toxic lead primarily enter the atmospheric air?
(A) Through the biological decay of marine organisms
(B) From motor vehicles using tetraethyl lead
(C) During the anaerobic decomposition of natural soil
(D) From agricultural runoff containing chemical fertilisers

Ans : (B)

Lead is a dangerous heavy metal pollutant with serious health implications. It historically enters the surrounding atmospheric air primarily through the exhaust emissions of motor vehicles. These vehicles rely on specific chemical additives, particularly tetraethyl lead, which impairs regular metabolic activities.

18. Which of the following statements are correct regarding the harmful effects of atmospheric pollution?
I. Benzene and toluene are suspected carcinogens that may lead to leukaemia.
II. Sulphur dioxide can be converted into sulphuric acid, damaging marble structures.
III. Nitrogen oxides can react with hydrocarbons to form stratospheric ozone.
IV. Increased levels of particulate pollutants are linked to heart disease and lung cancer.
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (B)

Atmospheric pollution causes numerous detrimental environmental effects. Benzene induces leukaemia, sulphur dioxide forms corrosive sulphuric acid, and particulates trigger severe heart diseases. However, nitrogen oxides react with surrounding hydrocarbons to form harmful ground-level photochemical smog, not the beneficial stratospheric ozone layer.

19. Pure water is neutral with a pH of 7. What is the approximate pH of normal, unpolluted rain?
(A) 7.0
(B) 5.6
(C) 3.5
(D) 2.0

Ans : (B)

Pure distilled water naturally maintains a neutral pH of exactly seven. However, normal rainwater is naturally slightly acidic because atmospheric carbon dioxide dissolves into falling droplets to form weak carbonic acid. This chemical dissolution predictably lowers its natural pH to about 5.6.

20. Which weak acid is naturally formed in normal rainwater due to the presence of carbon dioxide

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CHAPTER 8

Atmospheric Pollution

SUMMARY

1. ATMOSPHERE:

The gaseous envelope surrounding the earth is called atmosphere. The atmosphere extends about 50 km above the sea level.
The atmosphere of the earth may be divided into several distinct layers.
(a) The troposphere
(b) Stratosphere and the ozone layer

1.1 Troposphere

It is the lowest portion of earth's atmosphere. It contains approximately 75% of earth's atmosphere more and 99% of its water vapour and aerosol.

1.2 Stratosphere

Stratosphere is the second major layer of earth's atmosphere, just above the troposphere. It is situated between about 10 km and 50 km above the sea level.

1.3 Ozone Layer

It absorbs 97-99% of sun's UV light, which is damaging the life on the earth. It is mainly located in the lower portion of the stratosphere from approximately 13 to 40 km above the sea level.

2. CAUSES OF AIR POLLUTION:

The tropospheric pollution or the air pollution is caused by the following pollutants:
(i) Gaseous air pollutants: This includes mainly oxides of sulphur, oxides of nitrogen, oxides of carbon, ozone, hydrogen sulphide, etc.
(ii) Particulate air pollutants: This includes smoke, dust, fumes, etc.

3. ATMOSPHERIC POLLUTANTS

Sulphur dioxide is one of the major atmospheric pollutants.
Sulphur dioxide is added into our environment by various activities like by burning of sulphur containing fuels, by burning of oils and during the roasting of sulphide ore in metallurgy.
The presence of sulphur dioxide in the atmosphere badly affects the human physiology. It causes severe headache, nausea, vomiting and in some cases it can prove fatal.

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4. ACID RAIN

Sulphur dioxide is oxidized by atmospheric oxygen to form sulphur trioxide which combines with water to form sulphuric acid. This acid gets washed down with the rain and causes acid rain.

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

The acid corrodes the limestone and metals of the buildings, bridges, etc.
Oxides of nitrogen are another major air pollutants which are introduced into the atmosphere by the burning of the fossil fuels in internal combustion engines which produce a very high temperature and thus nitrogen and oxygen of air combine to form nitric oxide.

$$N_2 + O_2 \longrightarrow \underset{\text{(Nitric oxide)}}{2NO}$$

Nitric oxide further combines with atmospheric oxygen to form nitrogen dioxide.

$$2NO + O_2 \longrightarrow 2NO_2$$

Nitrogen dioxide combines with rain water and oxygen to form nitric acid which comes to the earth in the form of acid rain.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

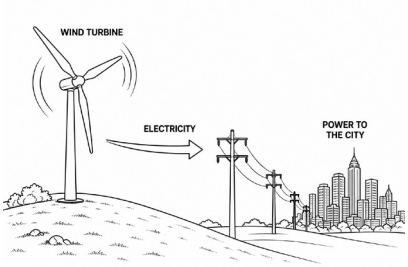
Nitrogen dioxide is a major atmospheric pollutant and adversely effects the human beings, plants and animals. The adverse effects of NO_2 are as follows:
(i) It causes irritation in mucous membrane.

(D) I, II, and IV

Ans : (A)

Acid rain predominantly forms when emitted nitrogen and sulphur oxides heavily react with atmospheric moisture. Nitrogen reacts with oxygen at elevated temperatures, eventually producing corrosive nitric acid. However, sulphur dioxide reacts with oxygen to form sulphur trioxide, not sulphate directly.

26. The technology shown in the diagram is a method for mitigating global warming. How does its use contribute to this goal?



(A) It increases the Earth's albedo, reflecting sunlight.
(B) It captures and sequesters carbon dioxide from the air.
(C) It generates electricity without burning fossil fuels.
(D) It releases aerosols that have a cooling effect.

Ans : (C)

Wind turbines harness kinetic energy from the wind to generate electricity. This is a renewable energy source that does not involve the combustion of fossil fuels like coal, oil, or natural gas. By replacing fossil-fuel-based power generation, wind energy reduces the emission of carbon dioxide and other greenhouse gases, thereby mitigating global warming.

27. How does acid rain primarily affect marine life in waterways?
(A) It increases the oxygen content in rivers and lakes.
(B) It lowers the pH of waterways, making survival difficult for aquatic animals.
(C) It promotes the excessive growth of blue-green algae.
(D) It rapidly raises the temperature of the water bodies.

Ans : (B)

Acid rain drastically alters the natural aquatic ecosystem environment. It significantly lowers the original pH of susceptible waterways. Most aquatic marine animals cannot survive when the water pH drops below four. Furthermore, specific sensitive fish species die completely below pH 5.5.

28. The table below links human activities to the greenhouse gases they primarily release. Based on the table, which gas is significantly produced by the anaerobic decomposition common in rice paddies and landfills?

Activity	**Primary Greenhouse Gas Released**
Burning of fossil fuels (coal, oil)	Carbon Dioxide (CO_2)
Use of aerosol sprays, refrigerants (older types)	Chlorofluorocarbons (CFCs)
Agricultural soil management, use of nitrogen fertilizers	Nitrous Oxide (N_2O)
Anaerobic decomposition in wetlands, rice paddies, landfills	Methane (CH_4)

(A) Carbon Dioxide (CO_2)
(B) Chlorofluorocarbons (CFCs)
(C) Nitrous Oxide (N_2O)
(D) Methane (CH_4)

Ans : (D)

The table directly associates methane (CH_4) with anaerobic decomposition, which is the process of bacterial decay in oxygen-poor environments. This process is prevalent in water-logged rice paddies and buried waste in landfills, making them significant man-made sources of methane. The other activities listed are primary sources for different greenhouse gases like CO_2 and N_2O.

29. What is the direct impact of acid rain on soil biology and chemistry?
(A) It enriches the soil with essential nutrients like nitrogen.
(B) It washes away essential nutrients and kills sensitive microbes.
(C) It permanently increases the agricultural productivity of barley.
(D) It neutralizes existing harmful alkaline minerals in the soil.

Ans : (B)

Acid rain inflicts immense structural damage upon vital agricultural lands. It actively washes

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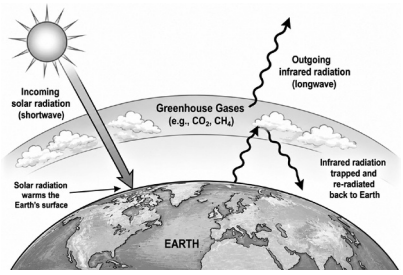
away crucial essential nutrients and minerals from the topsoil. Furthermore, it permanently alters the fundamental soil biology by killing numerous beneficial microbes that remain unable to tolerate low pH.

30. The diagram illustrates the mechanism that keeps Earth's surface warmer than it would otherwise be. What is the primary function of the layer labeled 'Greenhouse Gases'?


Incoming solar radiation (shortwave)
Outgoing infrared radiation (longwave)
Greenhouse Gases (e.g., CO_2, CH_4)
Infrared radiation trapped and re-radiated back to Earth
Solar radiation warms the Earth's surface
EARTH

(A) To absorb incoming ultraviolet light
(B) To trap outgoing infrared radiation
(C) To generate protective ozone
(D) To reflect incoming visible light

Ans : (B)

The Earth's surface absorbs solar radiation and re-emits energy as infrared (heat) radiation. Greenhouse gases in the atmosphere, such as CO_2 and CH_4, are transparent to incoming sunlight but absorb this outgoing infrared radiation. They then re-radiate it, trapping heat and warming the lower atmosphere and the planet's surface.

31. Match the air pollutants in List-I with their corresponding health or environmental impact in List-II.

List-I (Pollutant)

P. Suspended particulate matter (SPM)
Q. Chloro-fluoro carbons (CFC)
R. Carbon dioxide (CO_2)
S. Ozone

List-II (Impact)

I. Reduces oxygen levels
II. Reduces the protective layer against ultraviolet rays
III. Gets lodged in lungs, damaging their functioning
IV. Causes burning, itching watery eyes

(A) P-III, Q-II, R-I, S-IV
(B) P-III, Q-IV, R-I, S-II
(C) P-IV, Q-II, R-III, S-I
(D) P-II, Q-III, R-I, S-IV

Ans : (A)

Various suspended particulate matters progressively lodge themselves deep inside delicate human lungs. Emitted chlorofluorocarbons notoriously deplete the crucial stratospheric ozone shield. Elevated carbon dioxide critically reduces atmospheric oxygen levels. Meanwhile, ground-level ozone severely causes burning, itching watery eyes and lowered respiratory resistance.

32. An experiment was conducted to test the effect of simulated acid rain on different building materials. Which material shows the highest susceptibility to acid rain?

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Material	Chemical Composition	Observation after exposure to acid rain
Marble	Calcium carbonate ($CaCO_3$)	Surface became pitted and corroded; visible fizzing
Granite	Silicate minerals	No visible change
Slate	Clay minerals	Slight discolouration but no structural damage
Stainless Steel	Iron-chromium alloy	No visible change

(A) Marble
(B) Granite
(C) Slate
(D) Stainless Steel

Ans : (A)

The observations clearly indicate that marble underwent significant corrosion and fizzing. This is because its main component, calcium carbonate, readily reacts with acids (like sulphuric and nitric acid in acid rain) to produce a salt, water, and carbon dioxide gas. The other materials, being more chemically inert, showed little to no effect.

33. **Assertion (A) :** Building materials such as marble and limestone are weakened by acid rain.
Reason (R) : Acid rain contains mineral acids like sulphuric acid and nitric acid that exert a dissolving action on these materials.

(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the

correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Historical monuments and urban buildings suffer heavy degradation from atmospheric pollution. Marble, limestone, and slate materials actively react with the highly corrosive sulphuric and nitric acids present within acid rain. This continuous chemical dissolving action significantly weakens their solid architectural structural integrity.

34. The table documents the average pH level and the status of the fish population in a lake over two decades in an industrial region. At which pH level does the data suggest the fish population faces a critical decline?

Year	Average Lake pH	Fish Population Status
2000	6.5	Thriving
2005	6.0	Healthy
2010	5.5	Stressed, reproduction affected
2015	4.8	Most species have disappeared
2020	4.1	Barren, no fish

(A) pH 6.0
(B) pH 5.5
(C) pH 4.8
(D) pH 4.1

Ans : (B)

According to the table, the fish population was healthy at pH 6.0 but became "Stressed, reproduction affected" when the pH dropped to 5.5. This marks the critical turning point where the ecosystem's health begins to collapse. At pH 4.8, most species are already gone, indicating the decline started at a higher pH.

35. Which of the following measures is recommended to reduce the impact of acid rain?
(A) Increasing the combustion of fossil fuels in homes
(B) Using coal and petroleum with high sulphur content
(C) Fitting transport vehicles with catalytic converters
(D) Removing air filters and scrubbers from industrial chimneys

Ans : (C)

Effective mitigation of acid rain demands strict control over vehicular and industrial emissions. Fitting modern transport vehicles with advanced catalytic converters successfully reduces toxic nitric oxide exhaust emissions. Additionally, industries must actively employ efficient air filters and chemical scrubbers to curb widespread atmospheric pollution.

36. What is the primary cause of the increase in the average temperature of the earth's surface, known as global warming?
(A) The sudden expansion of the atmospheric ozone layer
(B) Most of the sun's energy being absorbed by the earth's surface and trapped by greenhouse gases
(C) The absorption of ultraviolet radiation by stratospheric oxygen
(D) The continuous release of volcanic ash blocking solar radiation

Ans : (B)

Deforestation and heavy fossil fuel burning continually alter atmospheric composition. Most incoming solar energy gets directly absorbed by the surface. Subsequently, elevated greenhouse gases trap this reflected thermal heat inside the atmosphere. This critical heat retention fundamentally causes widespread global warming phenomena.

37. Which of the following gases is NOT considered a greenhouse gas?
(A) Methane
(B) Nitrous oxide
(C) Argon
(D) Water vapour

Ans : (C)

The atmospheric greenhouse effect relies on specific heat-trapping chemical compounds. Carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, and water vapour act as primary greenhouse gases around the planet. Argon remains a chemically inert noble gas and completely lacks any greenhouse warming capabilities.

38. How do greenhouse gases regulate the temperature of the earth?
(A) They reflect all incoming sunlight back into space before it reaches the surface.
(B) They allow heat from the sun to enter but do not allow radiated heat to escape back into space.
(C) They absorb heat from the earth's core and distribute it throughout the atmosphere.

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phytoplankton, disrupts fundamental global food chains, and significantly reduces essential plant chlorophyll content across agricultural regions.

58. What is released when CFCs are broken down by powerful UV radiation in the stratosphere, triggering the destruction of ozone?
(A) Free fluorine radicals
(B) Free carbon atoms
(C) Chlorine free radicals
(D) Hydrogen ions

Ans : (C)

When inert synthetic chlorofluorocarbons finally reach the high stratosphere, intense ultraviolet radiation forcibly breaks their strong molecular bonds. This violent photochemical degradation continuously releases highly reactive chlorine free radicals. These aggressive chlorine radicals then systematically attack and destroy millions of vital protective ozone molecules.

59. Global warming leads to several major environmental consequences. The table below links these effects to their direct causes but contains a placeholder 'Z'. Identify the correct direct cause for 'Z'.

Consequence	Direct Cause
Rise in global sea levels	Melting of glaciers and polar ice caps
Changes in agricultural patterns	Alteration of regional temperature and rainfall
Z	Weakening of the human immune system
Damage to marine ecosystems like coral reefs	Increased ocean temperatures and acidification

(A) Z is the depletion of the ozone layer
(B) Z is an increase in acid rain
(C) Z is an increase in vector-borne diseases
(D) Z is a change in ocean currents

Ans : (A)

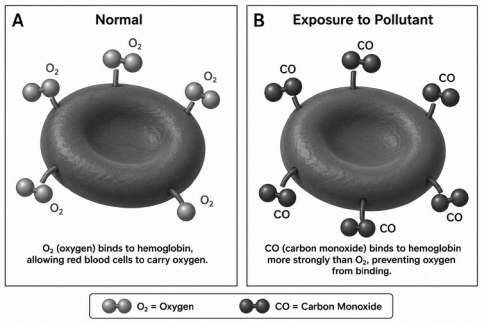
The question asks for the direct cause of a weakened immune system, which is a known consequence of increased exposure to UV-B radiation. This increased exposure is a direct result of the depletion of the stratospheric ozone layer, a separate environmental issue often discussed alongside global warming. The other options are consequences, not direct causes.

60. Why are oceans considered to be hit hard by the depletion of the ozone layer?
(A) The increase in UV radiation directly boils the surface water.
(B) Phytoplankton, the base of the marine food chain, cannot survive increased UV exposure.
(C) UV radiation chemically turns saltwater into acidic freshwater.
(D) The ozone hole allows marine animals to escape into the atmosphere.

Ans : (B)

The global marine ecosystem remains highly vulnerable to intense ultraviolet radiation. Microscopic surface-dwelling phytoplankton fundamentally form the critical base of marine food webs. Excessive ultraviolet exposure severely hinders their survival. Their rapid death inevitably triggers the subsequent mass starvation of countless dependent aquatic animal species.

61. The diagram illustrates the comparative binding affinity of two different gas molecules to a component of red blood cells. The process shown in Panel B leads to asphyxiation. Which pollutant is responsible for this effect?


A
Normal
B
Exposure to Pollutant
O2 (oxygen) binds to hemoglobin, allowing red blood cells to carry oxygen.
CO (carbon monoxide) binds to hemoglobin more strongly than O2, preventing oxygen from binding.
O2 = Oxygen
CO = Carbon Monoxide

(A) Carbon dioxide
(B) Nitrogen dioxide
(C) Carbon monoxide
(D) Sulphur trioxide

Ans : (C)

Carbon monoxide has a much higher affinity for haemoglobin in red blood cells than oxygen. When inhaled, it binds tightly to form carboxyhaemoglobin, severely reducing the blood's oxygen-carrying capacity. This deprivation of oxygen to tissues and organs is what leads to poisoning and, at high concentrations, asphyxiation.

62. The table provides data on the relative contribution of different gases to the man-made

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stratosphere

Ans : (C)

Uncontrolled global warming drastically disturbs the delicate planetary climate system. As average global temperatures continuously rise, massive glaciers and polar ice caps progressively melt. This massive influx of freshwater significantly raises ocean sea levels, inevitably threatening to flood numerous low-lying coastal coastal areas globally.

44. The formation and destruction of ozone in the stratosphere is a natural cycle. The table shows a simplified sequence of this process. Identify the chemical species represented by 'X' and 'Y'.

Step	Reaction	Description
1	O_2 + UV radiation → X	Photodissociation of oxygen molecule
2	X + O_2 → Y	Formation of ozone
3	Y + UV radiation → O_2 + X	Decomposition of ozone

(A) X is O_3, Y is O
(B) X is O, Y is O_3
(C) X is O_2, Y is O_3
(D) X is O, Y is O_2

Ans : (B)

In Step 1, high-energy UV radiation splits an oxygen molecule (O_2) into two separate oxygen atoms, so X is an atomic oxygen (O). In Step 2, this highly reactive atomic oxygen (X) combines with an oxygen molecule (O_2) to form an ozone molecule (O_3), so Y is ozone. This correctly represents the natural ozone formation cycle.

45. Which everyday action is recommended to restrain global warming by saving energy?
(A) Leaving electronic devices turned on when not in use
(B) Using cold water instead of hot water to save 500 pounds of carbon every year
(C) Cutting down mature trees to increase open space for cooling
(D) Increasing the exclusive use of fossil fuel-powered vehicles

Ans : (B)

Restraining modern global warming requires adopting multiple sustainable energy practices daily. Using cold water instead of heated water efficiently conserves significant energy resources, subsequently saving numerous pounds of carbon emissions annually. Additionally, switching off unused electronics and planting trees substantially reduce atmospheric carbon dioxide.

46. Which of the following statements correctly identify the sources of specific greenhouse gases?
I. Carbon dioxide is produced by the biological decay of plants and respiration by organisms.
II. Water vapour is primarily produced by the burning of hydrocarbons.
III. Oxides of nitrogen are formed when nitrogen and oxygen react at high temperatures in automobiles.
IV. Methane is solely produced by the aerobic respiration of marine animals.
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (A)

Greenhouse gases originate from diverse terrestrial activities. Biological decay, aerobic respiration, and fossil fuel combustion release massive carbon dioxide. Burning hydrocarbons extensively produces water vapour. Automobiles chemically generate nitrogen oxides under high temperatures. However, methane fundamentally results from anaerobic, not aerobic, decomposition processes.

47. **Assertion (A) :** Global warming can lead to major disruptions in natural wildlife habitats.
Reason (R) : Changes in rain patterns due to global warming affect trees and plants in forests, causing many species of wildlife to die out.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Accelerated global warming fundamentally alters established planetary precipitation cycles. These drastic shifts in traditional rain patterns heavily stress vulnerable forest vegetation. The subsequent widespread destruction of these critical natural floral habitats leaves dependent wildlife species facing severe starvation, displacement, and eventual massive extinction.

48. In which layer of the atmosphere is nearly 90% of the earth's ozone situated?

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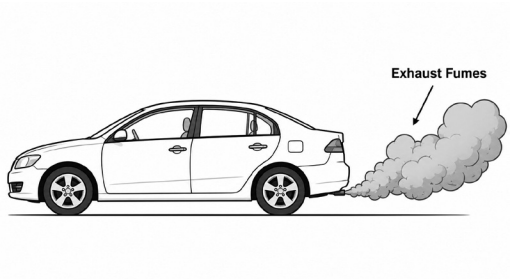
(A) Troposphere
(B) Stratosphere
(C) Mesosphere
(D) Thermosphere

Ans : (B)

Ozone exists as a pale-blue gaseous substance possessing a distinctly peculiar pungent smell. Almost ninety percent of this vital protective atmospheric ozone constantly resides within the stratosphere. This crucial layer systematically extends between ten to forty kilometres directly above the rocky earth's surface.

49. The diagram illustrates a common source of urban air pollution. Which pollutant, resulting from the incomplete combustion of fossil fuels in the vehicle's engine, is a major component of this exhaust?



(A) Carbon monoxide
(B) Sulphur dioxide
(C) Methane
(D) Ozone

Ans : (A)

The incomplete combustion of petrol or diesel in automobile engines produces carbon monoxide (CO), a hazardous gas. While other pollutants are present, CO is a principal product of this specific process. Sulphur dioxide is primarily from burning coal, methane from decomposition, and ozone is a secondary pollutant.

50. How is ozone continuously generated in the stratosphere?
(A) By the reaction of carbon dioxide with water vapour
(B) By the breakdown of oxygen molecules into oxygen atoms by high-energy far UV radiations
(C) Through the anaerobic decomposition of atmospheric organic matter
(D) By the combination of nitrogen oxides with atmospheric hydrocarbons

Ans : (B)

Stratospheric ozone continuously forms through vital photochemical interactions. Extremely high-energy ultraviolet radiations, specifically known as far UV, aggressively split stable atmospheric oxygen molecules into highly reactive separate oxygen atoms. These individual oxygen atoms then rapidly combine with intact oxygen molecules to form ozone.

51. Ozone is thermodynamically unstable. What happens when it absorbs UV radiation?
(A) It permanently condenses into liquid ozone droplets.
(B) It chemically bonds with nitrogen to form nitrous oxide.
(C) It gets decomposed to give back molecular oxygen and oxygen atoms.
(D) It immediately sinks to the troposphere to form smog.

Ans : (C)

The natural atmospheric ozone layer exhibits significant thermodynamic instability. Whenever stratospheric ozone molecules actively absorb incoming intense ultraviolet radiation, they rapidly decompose. This critical protective photochemical breakdown continuously reverts the ozone back into free molecular oxygen alongside individual reactive oxygen atoms.

52. Which type of harmful solar radiation is primarily absorbed by the ozone layer, protecting life on earth from skin cancer and DNA damage?
(A) Infrared radiation
(B) Visible light
(C) UV-A radiation
(D) UV-B radiation

Ans : (D)

The concentrated stratospheric ozone layer crucially protects the biosphere from dangerous solar energy. While it naturally filters multiple wavelengths, it effectively absorbs highly damaging UV-B radiations. This specific ultraviolet exposure remains heavily responsible for producing severe skin cancer, cataracts, and critical cellular DNA damage.

53. **Assertion (A) :** The overall amount of ozone in the stratosphere remains essentially constant in a natural cycle.
Reason (R) : A dynamic equilibrium exists between the continuous formation and decomposition of ozone by UV radiation.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A

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(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

Under strictly normal undisturbed atmospheric conditions, stratospheric ozone concentration maintains stability. This absolute constancy occurs because a perfect dynamic equilibrium naturally exists. The continuous vital generation of protective ozone molecules perfectly balances their simultaneous continuous photochemical destruction caused by incoming ultraviolet solar radiation.

54. The table lists two pollutants, their origins, and one of their major environmental impacts. Based on this information, which statement correctly differentiates Pollutant A from Pollutant B?

Pollutant	**Origin**	**Major Environmental Impact**
A	Produced from burning coal, petrol, and diesel	Contributes to Acid Rain
B	Released from refrigerators and air-conditioning systems	Causes Ozone Layer Depletion

(A) Pollutant A is an oxide of nitrogen, and Pollutant B is methane.
(B) Pollutant A is sulphur dioxide, and Pollutant B is a chlorofluorocarbon.
(C) Pollutant A is carbon monoxide, and Pollutant B is an oxide of nitrogen.
(D) Pollutant A is a hydrocarbon, and Pollutant B is sulphur dioxide.

Ans : (B)

The table describes Pollutant A as a product of burning fossil fuels that causes acid rain, which is characteristic of sulphur dioxide (SO_2). It describes Pollutant B as being released from refrigeration systems and causing ozone depletion, which perfectly matches the description of chlorofluorocarbons (CFCs). The other options incorrectly pair the pollutants with their descriptions.

55. In which year did scientists famously notice an "ozone hole" above Antarctica?
(A) 1960
(B) 1970
(C) 1980
(D) 1990

Ans : (C)

Extensive scientific monitoring historically revealed alarming atmospheric changes over polar regions. Severe ozone depletion physically results in a dangerous reduction of protective gas in the upper atmospheric layers. Notably, concerned atmospheric scientists formally detected a massive alarming ozone hole positioned directly above Antarctica during 1980.

NODIA

56. Chlorofluorocarbons (CFCs), also called freons, are major Ozone Depleting Substances. Which of the following describes the chemical nature of freons in the lower atmosphere?
(A) Highly toxic and flammable
(B) Chemically inert, non-toxic, and extremely stable
(C) Highly reactive with oxygen and rain
(D) Unstable and quickly broken down by visible light

Ans : (B)

Modern industries heavily utilise synthetic chlorofluorocarbons as reliable refrigerants and effective blowing agents. These commercial freons constitute non-toxic, completely non-inflammable, and incredibly stable chemical compounds. Due to being chemically inert, they easily resist dissolving in atmospheric rain, steadily migrating upwards completely unmodified by surrounding winds.

57. Which of the following are consequences of the depletion of the ozone layer?
I. Increased incidence of malaria due to a weakened human immune system.
II. Disruption of the food chain because phytoplankton may not survive.
III. Decrease in the chlorophyll content of plants, affecting vegetable quality.
IV. Massive drop in the earth's average surface temperature.
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

Ans : (A)

Unchecked severe stratospheric ozone depletion triggers massive ecological disasters globally. Elevated ultraviolet exposure dangerously weakens human immune responses, increasing infectious disease incidence. Additionally, excessive radiation utterly destroys vital marine

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(D) They convert solar radiation into cooling ultraviolet rays.

Ans : (B)

Greenhouse gases dynamically function much like the transparent glass panels of an agricultural greenhouse. They easily allow incoming solar radiation to enter the atmosphere. However, they effectively trap the outgoing radiated surface heat, strictly preventing it from escaping back into cold space.

39. What is the main source of methane emissions in the environment?
(A) Burning of hydrocarbons in automobiles
(B) High-temperature combustion of fossil fuels
(C) Anaerobic decomposition of organic matter in soil and water
(D) Biological respiration by plants and animals

Ans : (C)

Various human and natural activities constantly release specific greenhouse gases. Methane is primarily emitted in remarkably large quantities during the prolonged anaerobic decomposition of decaying organic matter found deep within soil, wetland sediments, and stagnant water, alongside the incomplete combustion of fossil fuels.

40. **Assertion (A) :** The greenhouse effect played a vital role in the biological evolution of the earth.
Reason (R) : Greenhouse gases trap solar heat like a soft blanket, keeping the earth's surface warm and making habitats better for living beings.
(A) Both A and R are true and R is the correct of A
(B) Both A and R are true but R is not the correct of A
(C) A is true but R is false
(D) A is false but R is true

Ans : (A)

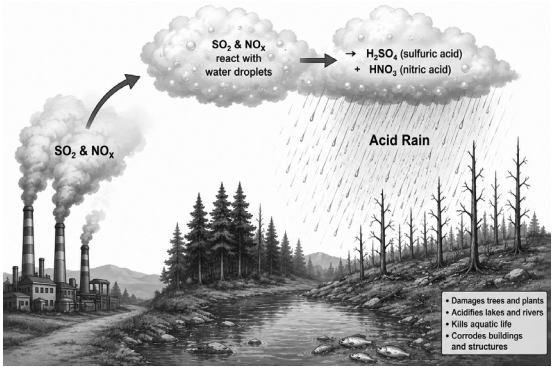
A balanced natural greenhouse effect inherently supports the flourishment of complex planetary life. By wrapping a thermal blanket around the globe, atmospheric greenhouse gases effectively trap essential solar heat. This critical warming mechanism keeps biological habitats remarkably hospitable for diverse species evolution.

41. What would likely happen to the earth if there were no carbon dioxide in the atmosphere to cause the greenhouse effect?
(A) The earth would experience extreme global warming.
(B) Too much solar radiation would escape back into space, turning the earth into a big snowball.
(C) The oceans would completely evaporate due to increased ultraviolet radiation.
(D) The ozone layer would thicken uncontrollably.

Ans : (B)

While excessive greenhouse gases cause severe problems, their baseline presence remains fundamentally necessary. If atmospheric carbon dioxide disappeared completely, excessive solar thermal radiation would instantly escape back into cold space. Consequently, our entire planet would freeze entirely, resembling a giant uninhabitable snowball.

42. The diagram illustrates the process by which primary industrial emissions are transformed in the atmosphere to create a form of secondary pollution. What phenomenon is depicted?


SO_2 & NO_x react with water droplets
H_2SO_4 (sulfuric acid) + HNO_3 (nitric acid)
SO_2 & NO_x
Acid Rain
• Damages trees and plants
• Acidifies lakes and rivers
• Kills aquatic life
• Corrodes buildings and structures

(A) Photochemical smog formation
(B) Greenhouse effect
(C) Ozone layer depletion
(D) Acid rain formation

Ans : (D)

The diagram clearly shows oxides of sulphur (SO_2) and nitrogen (NOx) being released from industrial sources. These primary pollutants react with atmospheric water, oxygen, and other chemicals to form sulphuric acid and nitric acid. These acids then dissolve in rainwater to fall as acid rain, a secondary pollutant.

43. Which of the following is a direct harmful effect of global warming?
(A) Decrease in the incidence of communicable diseases
(B) Increase in the global agricultural crop yield
(C) Gradual melting of polar ice caps leading to a rise in sea levels
(D) Thickening of the ozone layer in the

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greenhouse effect. Which gas is the single largest contributor?

Greenhouse Gas	**Approximate Contribution to Enhanced Greenhouse Effect (%)**
Carbon Dioxide (CO_2)	60%
Methane (CH_4)	20%
Chlorofluorocarbons (CFCs)	14%
Nitrous Oxide (N_2O)	6%

(A) Carbon Dioxide
(B) Methane
(C) Chlorofluorocarbons
(D) Nitrous Oxide

Ans : (A)

(B) analyzing the data presented, carbon dioxide (CO_2) is shown to be responsible for approximately 60% of the enhanced (man-made) greenhouse effect. This is a significantly larger share than that of methane (20%), CFCs (14%), or nitrous oxide (6%). Therefore, carbon dioxide is the primary driver of global warming from human activities.

63. Apart from CFCs, which of the following is also considered a chemical responsible for the depletion of the ozone layer?
(A) Carbon monoxide (CO)
(B) Methyl bromide (CH_3Br)
(C) Sulphur dioxide (SO_2)
(D) Argon (Ar)

Ans : (B)

While synthetic chlorofluorocarbons notoriously act as primary ozone-depleting substances, various other industrial chemical compounds simultaneously inflict similar atmospheric damage. Halogen-containing industrial chemicals like methyl chloride, carbon tetrachloride, halons, and notably methyl bromide aggressively participate in destroying the protective stratospheric ozone layer through radical chain reactions.

64. Under normal conditions, ozone molecules are destroyed when they react with atmospheric pollutants. Which specific pollutant is primarily mentioned as a natural destroyer of ozone before human interference?
(A) Carbon dioxide
(B) Oxides of nitrogen
(C) Methane
(D) Helium

Ans : (B)

Even without human interference, some natural atmospheric ozone destruction constantly occurs. The natural dynamic equilibrium relies upon continuous complex chemical interactions. Naturally generated pollutants, explicitly including reactive oxides of nitrogen alongside atmospheric free radicals, constantly react with and efficiently destroy vulnerable ozone molecules.

65. In the reaction $CF_2Cl_2(g) \rightarrow Cl(g) + CF_2Cl(g)$, what role does the released chlorine free radical (Cl) play after it reacts with ozone?
(A) It permanently bonds with oxygen and settles in the troposphere.
(B) It is regenerated at the end of the reaction cycle to destroy more ozone molecules.
(C) It transforms back into a stable CFC molecule instantly.
(D) It neutralises harmful UV radiation directly.

Ans : (B)

The extreme destructive danger of atmospheric chlorine stems entirely from its relentless cyclic chemical behaviour. After violently breaking apart a protective ozone molecule, the reactive chlorine free radical systematically regenerates. Consequently, a single persistent chlorine radical continuously destroys countless millions of vital ozone molecules over time.

66. How does an increase in UV radiation directly affect economically important crops such as rice?
(A) It severely damages the cyanobacteria residing on their roots, which are essential for nitrogen retention.
(B) It causes the rice grains to instantly mutate into toxic variants.
(C) It forces the plant roots to absorb excessive amounts of carbon dioxide.
(D) It makes the soil overly acidic, completely halting seed germination.

Ans : (A)

Elevated ultraviolet radiation significantly threatens vital global agricultural security. Economically crucial cereal crops, particularly flooded rice, inherently depend upon symbiotic microscopic cyanobacteria residing upon their root systems for crucial nitrogen retention. Unfortunately, these highly sensitive agricultural

NODIA

cyanobacteria easily perish under excessively intense atmospheric ultraviolet exposure.

67. While ozone makes up a tiny fraction of the entire atmosphere, where is its concentration the highest?
(A) Near the earth's surface, acting as a thick thermal blanket.
(B) Scattered evenly throughout the entire 1600 km height of the atmosphere.
(C) In a thin layer in the upper levels of the stratosphere, between 15 to 50 km above the earth's surface.
(D) Deep within the dense atmospheric clouds over the equatorial oceans.

Ans : (C)

The total atmospheric volume contains remarkably minuscule absolute quantities of ozone gas. However, its highest critical concentration specifically exists clumped together. This vital protective layer safely envelops the earth precisely within the high upper stratospheric regions, situated approximately between fifteen to fifty kilometres entirely above ground.

68. The gaseous envelope surrounding the Earth is called:
(A) Hydrosphere
(B) Lithosphere
(C) Atmosphere
(D) Biosphere

Ans : (C)

Explanation: The atmosphere is the layer of gases surrounding the Earth. It extends approximately 50 km above sea level and contains gases essential for life. It protects living organisms from harmful solar radiations and helps maintain suitable climatic conditions. The atmosphere consists of different layers, including the troposphere and stratosphere.

69. Which layer contains about 75% of the Earth's atmosphere and most of its water vapour?
(A) Stratosphere
(B) Ozone Layer
(C) Troposphere
(D) Mesosphere

Ans : (C)

Explanation: The troposphere is the lowest layer of the atmosphere. It contains nearly 75% of the atmospheric gases and about 99% of water vapour and aerosols. Most weather phenomena such as clouds, rainfall and storms occur in this layer, making it the most important layer for life on Earth.

70. The ozone layer is mainly present in the:
(A) Troposphere
(B) Stratosphere
(C) Mesosphere
(D) Thermosphere

Ans : (B)

Explanation: The ozone layer is located mainly in the lower stratosphere, approximately 13–40 km above sea level. It absorbs 97–99% of harmful ultraviolet (UV) radiation from the Sun. Without this protective layer, living organisms would be exposed to dangerous UV rays that can cause skin diseases and other biological damage.

71. Which gas is a major atmospheric pollutant responsible for acid rain?
(A) Oxygen
(B) Nitrogen
(C) Sulphur dioxide
(D) Hydrogen

Ans : (C)

Explanation: Sulphur dioxide (SO_2) is released into the atmosphere through burning sulphur-containing fuels and industrial processes. It gets oxidized to sulphur trioxide, which reacts with water to form sulphuric acid. This acid falls with rainwater as acid rain, damaging buildings, monuments, soil and aquatic life.

72. Nitrogen dioxide is mainly produced by:
(A) Photosynthesis
(B) Internal combustion engines
(C) Respiration
(D) Evaporation

Ans : (B)

Explanation: Nitrogen dioxide is produced when nitrogen and oxygen combine at the very high temperatures generated in internal combustion engines. It is a harmful pollutant that affects human health, damages plants and contributes to the formation of acid rain and photochemical smog.

73. Which of the following is NOT an effect of acid rain?
(A) Damage to buildings
(B) Soil nutrient loss
(C) Increased fish survival
(D) Damage to plant leaves

Ans : (C)

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Explanation: Acid rain increases the acidity of lakes and rivers, making them unsuitable for aquatic life. Fish and other aquatic organisms often die in highly acidic water. Acid rain also damages vegetation, removes essential soil nutrients and corrodes buildings and monuments.

74. Global warming is mainly caused by:
(A) Decrease in oxygen
(B) Increase in greenhouse gases
(C) Increase in nitrogen
(D) Ozone formation

Ans : (B)

Explanation: Global warming occurs because greenhouse gases trap infrared radiation emitted by the Earth's surface. Carbon dioxide, methane and other greenhouse gases prevent heat from escaping into space, causing the Earth's average temperature to rise gradually. This phenomenon is known as the greenhouse effect.

75. Which of the following is a greenhouse gas?
(A) Carbon dioxide
(B) Helium
(C) Neon
(D) Argon

Ans : (A)

Explanation: Carbon dioxide is one of the most important greenhouse gases. It absorbs infrared radiation emitted by the Earth's surface and traps heat within the atmosphere. Other greenhouse gases include methane, water vapour, ozone, nitrous oxide and chlorofluorocarbons (CFCs).

76. Which practice helps reduce greenhouse gases in the atmosphere?
(A) Deforestation
(B) Increased fossil fuel use
(C) Afforestation
(D) Burning more coal

Ans : (C)

Explanation: Afforestation means planting more trees and increasing forest cover. Trees absorb carbon dioxide during photosynthesis and help reduce its concentration in the atmosphere. This lowers the greenhouse effect and helps control global warming. Afforestation is considered one of the most effective environmental conservation measures.

77. The major cause of ozone layer depletion is:
(A) Oxygen gas
(B) Carbon dioxide
(C) Chlorofluorocarbons (CFCs)
(D) Water vapour

Ans : (C)

Explanation: Chlorofluorocarbons (CFCs), released from refrigerators, air conditioners and aerosol sprays, are the major cause of ozone depletion. They break down ozone molecules in the stratosphere, creating ozone holes. This allows more harmful ultraviolet radiation to reach the Earth's surface, increasing the risk of skin cancer and other health problems.

ONE MARK QUESTIONS

NODIA

78. A student observes that the ozone layer is becoming thinner over Antarctica. Which human activity is most directly responsible for this phenomenon?

Ans :

Excessive use of chlorofluorocarbons (CFCs).

79. Acid rain damages marble monuments more severely than glass buildings. Which component of marble is affected by acid rain?

Ans :

Calcium carbonate.

80. A factory releases large quantities of sulphur dioxide into the atmosphere. Which environmental problem is most likely to increase in the surrounding area?

Ans :

Acid rain.

81. A city records a sharp increase in respiratory diseases during winter due to the accumulation of smoke and harmful gases. What type of pollution is indicated?

Ans :

Air pollution.

82. A scientist finds that a gas absorbs outgoing infrared radiation and traps heat in the atmosphere. What type of gas is being described?

Ans :

Greenhouse gas.

83. A student claims that global warming and ozone depletion are the same phenomenon. Is the statement correct?

Ans :

(ii) Aquatic organisms find it difficult to survive in acidic conditions.
(iii) As a result, the fish population decreases.

160. A city experiences frequent smog formation during winter mornings. Explain how nitrogen dioxide contributes to this problem.

Ans :
(i) Nitrogen dioxide is released from vehicle exhausts.
(ii) In the presence of sunlight, it forms photochemical smog.
(iii) Smog causes eye irritation and respiratory disorders.

161. An environmentalist claims that increasing the number of vehicles on roads can accelerate global warming. Justify the statement.

Ans :
(i) Vehicles burn fossil fuels and release carbon dioxide.
(ii) Carbon dioxide is a greenhouse gas.
(iii) Increased greenhouse gases enhance global warming.

162. A scientist warns that continued melting of glaciers may create serious environmental problems. Explain.

Ans :
(i) Global warming causes glaciers and polar ice caps to melt.
(ii) Sea levels rise due to the addition of water.
(iii) Low-lying coastal regions may get submerged.

163. A student argues that the ozone layer is essential for life on Earth. Support the statement.

Ans :
(i) Ozone absorbs harmful ultraviolet radiations.
(ii) It prevents excessive UV rays from reaching Earth.
(iii) This protects living organisms from skin diseases and genetic damage.

164. A country decides to ban products containing CFCs. Explain the scientific reason behind this decision.

Ans :
(i) CFCs destroy ozone molecules in the stratosphere.
(ii) This causes depletion of the ozone layer.
(iii) More harmful UV radiations then reach the Earth's surface.

165. A marble monument located near industrial zones is gradually losing its shine. Explain the reason.

Ans :
(i) Industries release sulphur dioxide and nitrogen oxides.
(ii) These gases form acids in rainwater.
(iii) Acid rain reacts with marble and causes erosion.

166. A student notices that afforestation is often suggested as a solution to global warming. Explain why.

Ans :
(i) Trees absorb carbon dioxide during photosynthesis.
(ii) This reduces the concentration of greenhouse gases.
(iii) As a result, global warming can be controlled.

167. Two cities have the same population, but one has more green cover. Which city is likely to experience lower levels of air pollution? Give reasons.

Ans :
(i) The city with more green cover.
(ii) Trees absorb pollutants and carbon dioxide.
(iii) They help improve air quality.

168. A teacher explains that the troposphere is important for life on Earth. Give three reasons.

Ans :
(i) It contains most of the atmospheric gases.
(ii) It contains nearly all the water vapour.
(iii) Weather phenomena occur in this layer.

169. During an environmental survey, scientists observe a gradual increase in Earth's average temperature. Explain how greenhouse gases contribute to this trend.

Ans :
(i) Greenhouse gases absorb outgoing infrared radiation.
(ii) The heat gets trapped in the atmosphere.
(iii) This raises the Earth's average temperature.

170. A student compares the functions of the ozone layer and greenhouse gases. State three

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Ans :

(B) the burning of fossil fuels.

103. Name the atmospheric pollutants.

Ans :

Oxides of nitrogen and sulphur.

104. How does global warming cause the change in sea-level?

Ans :

The global warming leads to the melting of glaciers due to increase in temperature, therefore, the sea level increases thus, submerging the low lying areas.

105. What is the function of ozone in stratosphere?

Ans :

To prevent harmful UV radiation to reach on the earth.

106. Give two major causes for the destruction of ozone layer.

Ans :

(i) Too much or excessive use of chlorofluorocarbon (CFC's).
(ii) Supersonic jets.

107. Articles made of silver metals lose lustre. Why?

Ans :

(A) it gets coated with black coloured silver sulphide due to the presence of H_2S.

108. What is acid rain?

Ans :

During rainfall, when the oxides of nitrogen and sulphur react with water, produce acid. This rainfall is termed as acid rain.

$$N_2 + O_2 \xrightarrow{\text{Thunder}} 2NO.$$

$$2NO + O_2 \xrightarrow{\text{Lightning}} 2NO_2$$

$$4NO_2 + O_2 + 2H_2O \longrightarrow \underset{\text{Acid rain}}{4HNO_3}$$

109. Define air pollution and write two major pollutants of air.

Ans :

Contamination of air by smoke, harmful gases, etc. is called air pollution. Two major pollutants are NO_2 and SO_2.

110. Describe the nature of infrared rays. Give sources of greenhouse gases.

Ans :

Infrared ray produce heat. Sources of greenhouse gases are CO_2, CH_4 and oxides of nitrogen.

111. What do you understand by ppm?

Ans :

Parts per million.

112. Fill in the blanks.
(i) Ozone absorbs the harmful _____ rays coming from the sun.
(ii) Carbon dioxide enters into atmosphere due to _____.
(iii) The rise in the average temperature of earth's surface is called _____.
(iv) Taj Mahal is made up of _____ which is chemically _____.
(v) The particulate pollutants include _____, _____, _____, _____, and _____.

Ans :

(i) ultraviolet
(ii) burning
(iii) global warming
(iv) marble, calcium carbonate
(v) dust, smoke, mist, fumes and spray

113. Fill in the blanks:
(i) Supersonic jets release oxides of _____ into the atmosphere.
(ii) _____ is due to accumulation of greenhouse gases.
(iii) _____ is released in large quantities by heaps of rotten and degradable matter.
(iv) _____ is released by burning of fuels and respiration of animals.

Ans :

(i) nitrogen
(ii) Global warming
(iii) Methane
(iv) Carbon dioxide

114. Fill in the blanks.
(i) Nitric oxide is _____ toxic.
(ii) The gaseous material which envelopes the earth is called _____.
(iii) The lowest region of the atmosphere is called _____.
(iv) Stratosphere mainly contains _____, _____ and ozone.
(v) Rain water containing H_2SO_4 and HNO_3 is called _____.

Ans :

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(i) highly
(ii) atmosphere
(iii) Troposphere
(iv) oxygen, Very little water vapour
(v) acid rains.

115. Fill in the blanks.
(i) Normal rain has pH between _____ and _____.
(ii) Metals lose _____ because of acid present in rain.
(iii) High flying jets and rockets release _____
(iv) The bond angle in ozone is _____.

Ans :
(i) 5.6 and 6.0
(ii) lustre
(iii) oxides of nitrogen
(iv) 116.8°

116. Name the following:
(i) A gas which contributes towards greenhouse effect.
(ii) Two gases which causes acid rain.
(iii) The oxide of nitrogen which causes greenhouse effect.
(iv) An allotrope of oxygen which causes greenhouse effect.
(v) Another name of greenhouse effect.

Ans :
(i) Carbon dioxide
(ii) Nitrogen dioxide and sulphur dioxide
(iii) Nitrous oxide
(iv) Ozone
(v) Global warming

117. State whether the following statements are True or False.
(i) Ozone is formed by the action of UV rays of the sun on oxygen.
(ii) The major gas which causes acid rain is water vapour.
(iii) Global warming increases the sea-level.
(iv) Global warming makes the environment healthy.
(v) A Photochemical smog is beneficial to human beings.

Ans :
(i) True (ii) False
(iii) True (iv) False
(v) False

118. Write one word for the following:
(i) The phenomenon having higher temperature inside as compared to outside by allowing solar energy to enter but prevent it from escaping.
(ii) Contributes to damage of trees at high elevations.
(iii) Substance formed by passing silent (sparkless) electric discharge.
(iv) A commonly used ozoniser.

Ans :
(i) Greenhouse effect
(ii) Acid rain
(iii) Ozone
(iv) Siemen's Ozoniser

TWO MARKS QUESTIONS

119. Write balanced chemical equation for the formation of acid rain.

Ans :

$$N_2 + O_2 \xrightarrow{\text{Thunder and lighting}} 2NO$$
$$2NO + O_2 \longrightarrow 2NO_2$$
$$4NO_2 + 2H_2O + O_2 \longrightarrow \underset{\text{(Acid rain)}}{4HNO_3}$$

120. What are the causes for the destruction of ozone layer?

Ans :

The major causes are:
(i) Excessive use of chlorofluorocarbon
(ii) Flying of supersonic planes.

121. How is sulphur dioxide added in the atmosphere?

Ans :

When sulphur present in fossil fuels is burnt, sulphur dioxide gas is produce

$$S + O_2 \xrightarrow{\text{burning}} SO_2$$

122. How does nitrogen dioxide enter in the atmosphere?

Ans :

(A) high temperature, in furnaces (> 1500 °C), nitrogen combine with oxygen present in air and forms nitric oxides. This nitric oxide combines with more oxygen present in air to form nitrogen dioxide.

$$N_2 + O_2 \xrightarrow[1500^\circ C]{\text{above}} 2NO$$
$$2NO + O_2 \longrightarrow 2NO_2$$

123. How is ozone formed in the atmosphere? Write the importance of ozone layer.

NODIA

Ans :

Ozone is formed about 50 km above from the earth's surface (stratosphere) by the action of ultraviolet light on oxygen molecules.

$$3O_2 \xrightarrow{\text{UV light}} \underset{\text{(Ozone)}}{2O_3}$$

Ozone shields most of the UV radiations and does not allow them to pass on the earth's surface.

124. How can we protect the ozone layer?

Ans :

Use of chlorofluorocarbons (CFCs) should be banned as they are widely used in refrigeration industry, insecticides, kinds of sprays, etc.

125. What are the different layers of atmosphere?

Ans :

There are four layers of atmosphere.
They are as follows:

(i) Troposphere (ii) Stratosphere
(iii) Mesosphere (iv) Exosphere.

126. What is the danger to the historical monuments made of marble?

Ans :

The historical monument made of marble are under the reeling danger of acid rain as the acid keep on dissolving the marble which is chemically calcium carbonate.

$$N_2 + O_2 \xrightarrow{\text{Thunder}} 2NO.$$

$$2NO + O_2 \xrightarrow{\text{Lightning}} 2NO_2$$

During rain fall

$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$$

Marble Monuments

$$CaCO_3 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O + CO_2$$

127. State three ways of minimizing global warming.

Ans :

(i) Afforestation
(ii) Reduce automobile pollution
(iii) Pollution from factories (steel).

128. What is greenhouse effect? Name the greenhouse gases.

Ans :

Several gases present in the atmosphere absorb heat coming from the sun and prevent it from escaping, thus keeping the earth's atmosphere warm. Such gases are called green house gases and this effect is called green house effect. Green house gases are CO_2, CH_4 (Methane) and oxides of nitrogen.

129. What is meant by the depletion of ozone layer?

Ans :

Depletion of Ozone Layer: Decrease of the ozone in the stratosphere is called the depletion of the ozone layer or the destruction of the ozone layer.

130. Why is acid rain considered a threat to Taj Mahal?

Ans :

Taj Mahal (one of the seven wonders of the world) made of marble which is chemically calcium carbonate is being eroded by the acid rain and if the emission of NO_2 and SO_2, are not stopped in the nearby refineries, then it can give a very ugly look to the Taj Mahal.

$$CaCO_3 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O + CO_2$$

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$$

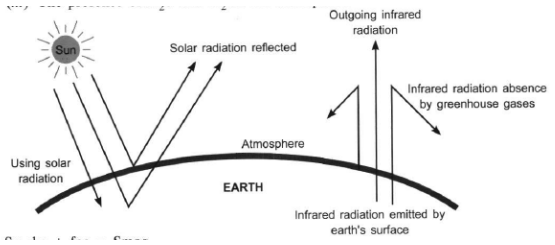
131. What are the causes of acid rain?

Ans :

(i) The presence of oxides of nitrogen, such as nitric oxide (NO) and Nitrogen dioxide (NO_2).
(ii) The presence of oxides of sulphur, such as SO_2.
(iii) The presence of H_2S and Cl_2 in the atmosphere.

132. Draw a diagram to show greenhouse effect.

Ans :



133. What is smog? State its damaging effects.

Ans :

Smog is a form of air pollution caused by a mixture of smoke and fog, formed when pollutants from vehicles and factories react with sunlight and moisture.

Damaging Effects:

(i) Premature death due to cancer.
(ii) Can aggravate health problems like

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No.

84. During heavy traffic, nitrogen dioxide concentration increases significantly. Name one organ of the human body most directly affected by this pollutant.

Ans :

Lungs.

85. The survival of aquatic organisms decreases after continuous acid rain in a lake. What change has occurred in the lake water?

Ans :

Its acidity has increased.

86. The ozone layer protects living organisms by absorbing which type of solar radiation?

Ans :

Ultraviolet (UV) radiation.

87. A teacher advises students to use public transport more frequently. Which environmental issue is this measure intended to reduce?

Ans :

Global warming.

88. An increase in atmospheric carbon dioxide primarily affects which environmental phenomenon?

Ans :

Greenhouse effect.

89. A region experiences excessive melting of glaciers over several years. Which global environmental problem does this indicate?

Ans :

Global warming.

90. A pilot flying at 20 km above sea level is travelling through which atmospheric layer?

Ans :

Stratosphere.

91. Photochemical smog is formed when nitrogen dioxide reacts in the presence of what factor?

Ans :

Sunlight.

92. A student notices irritation in the eyes while walking through heavy smog. Which atmospheric condition is most likely responsible?

Ans :

Photochemical smog.

93. Which atmospheric layer contains the maximum amount of water vapour?

Ans :

Troposphere.

94. A researcher identifies a gas that contributes to both greenhouse effect and atmospheric warming. Name the gas.

Ans :

Carbon dioxide.

95. Why is afforestation considered an effective method for controlling global warming?

Ans :

Trees absorb carbon dioxide.

96. A scientist predicts that low-lying coastal regions may disappear in the future. Which environmental issue is responsible?

Ans :

Global warming.

97. An environmentalist campaigns against the use of CFC-based refrigerants. Which atmospheric layer is being protected?

Ans :

Ozone layer.

98. What is the full form of CFC?

Ans :

Chlorofluorocarbon.

99. Give equation for the formation of ozone in the atmosphere.

Ans :

$$3O_2 \xrightarrow{\text{UV rays}} 2O_3$$

100. Define atmosphere.

Ans :

The gaseous envelope surrounding the earth is called atmosphere.

101. Define pollution.

Ans :

Any undesirable change in our natural environment is called pollution.

102. What is the main source of sulphur dioxide in the atmosphere?

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carbonate).
(ii) The surface gradually gets corroded and damaged.

147. Why is nitrogen dioxide considered a harmful air pollutant?

Ans :
(i) It irritates the mucous membrane and lungs.
(ii) It damages plant leaves and contributes to smog formation.

148. A region experiences rapid melting of glaciers. State two environmental consequences of this change.

Ans :
(i) Rise in sea level.
(ii) Submergence of low-lying coastal areas.

149. A student notices that the troposphere contains most of the water vapour present in the atmosphere. State two significances of this fact.

Ans :
(i) Weather changes occur mainly in the troposphere.
(ii) Cloud formation and rainfall take place in this layer.

150. A teacher asks students to reduce the use of private vehicles. How can this help the environment?

Ans :
(i) It reduces the emission of greenhouse gases.
(ii) It helps in controlling air pollution.

151. Why is sulphur dioxide called a major atmospheric pollutant?

Ans :
(i) It contributes to acid rain formation.
(ii) It adversely affects human health.

152. A scientist warns that continued ozone depletion can affect life on Earth. Give two reasons.

Ans :
(i) More harmful UV rays will reach the Earth's surface.
(ii) The risk of skin diseases will increase.

153. How does acid rain affect soil quality?

Ans :
(i) It removes essential nutrients from the soil.
(ii) It decreases soil fertility.

154. A factory owner installs pollution-control devices in chimneys. State two benefits of this measure.

Ans :
(i) Reduction in air pollution.
(ii) Lower emission of harmful gases such as SO_2.

155. Why are greenhouse gases important in the study of global warming?

Ans :
(i) They trap outgoing infrared radiation.
(ii) They increase the Earth's average temperature.

156. A student compares the functions of the troposphere and stratosphere. State one important feature of each.

Ans :
(i) Troposphere contains most of the water vapour.
(ii) Stratosphere contains the ozone layer.

157. Explain why acid rain is considered harmful to both living and non-living things.

Ans :
(i) It damages plants and aquatic life.
(ii) It corrodes buildings, monuments and metals.

THREE MARKS QUESTIONS

158. A factory located near a town continuously emits sulphur dioxide into the atmosphere. After a few years, nearby buildings show signs of corrosion and residents report respiratory problems.

Ans :
(i) Sulphur dioxide reacts with oxygen and water to form sulphuric acid.
(ii) The acid falls as acid rain and corrodes buildings.
(iii) Sulphur dioxide also affects the respiratory system causing health problems.

159. A lake situated near an industrial area has shown a decline in fish population over the years. Scientists suspect acid rain to be the cause.

Ans :
(i) Acid rain increases the acidity of the lake water.

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asthama, chronic bronchitis, etc.
(iii) Causes eyes irritation.
(iv) It also inhibits the growth of plants.

134. Define ozone layer depletion.

Ans :

Ozone layer depletion refers to the phenomenon of reduction in the amount of ozone in the stratosphere. It varies geographically and by season.

135. In which unit the thickness of ozone layer is measured?

Ans :

Dobson Unit (DU) is the unit which measures the thickness of the ozone layer. It equals to 0.01 mm thickness.

136. What does CFC stand for? Write its role in the atmosphere.

Ans :

CFC stands for chlorofluorocarbon. It is a major pollutant of atmosphere.

137. Greenhouse effect is useful for the existence of life on the earth. Justify.

Ans :

(A) the green house effect helps to maintain the heat which is also required for the sustainance of life on earth.

138. A factory located near a residential area releases sulphur dioxide into the atmosphere. Explain how this pollutant can affect both human beings and buildings.

Ans :

(i) It causes headache, nausea and respiratory problems in humans.
(ii) It leads to acid rain which corrodes buildings and monuments.

139. A lake receives water from an area frequently affected by acid rain. Predict two consequences for the aquatic ecosystem.

Ans :

(i) The acidity of the lake water increases.
(ii) Aquatic organisms such as fishes may not survive.

140. A student observes that vehicles contribute significantly to air pollution. State two pollutants released due to the burning of fossil fuels in automobiles.

Ans :

(i) Nitrogen oxides.
(ii) Carbon dioxide.

141. An environmentalist recommends planting more trees to control global warming. Give two reasons for this suggestion.

Ans :

(i) Trees absorb carbon dioxide from the atmosphere.
(ii) They help reduce the greenhouse effect.

142. A scientist describes ozone as a protective shield around the Earth. Justify this statement with two points.

Ans :

(i) Ozone absorbs harmful UV radiations.
(ii) It protects living organisms from skin diseases and other harmful effects.

143. A city records increasing cases of eye irritation and asthma attacks during summer afternoons. Which atmospheric phenomenon may be responsible? Give two effects.

Ans :

(i) Photochemical smog may be responsible.
(ii) It causes eye irritation and respiratory problems.

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144. The use of CFC-based products is discouraged worldwide. State two reasons.

Ans :

(i) CFCs cause depletion of the ozone layer.
(ii) Ozone depletion allows harmful UV rays to reach the Earth.

145. A student differentiates between global warming and ozone depletion. State any two differences.

Ans :

(i) Global warming is caused by greenhouse gases, whereas ozone depletion is mainly caused by CFCs.
(ii) Global warming increases Earth's temperature, whereas ozone depletion increases UV radiation reaching Earth.

146. A monument made of marble is showing signs of damage after years of exposure to polluted rainwater. Explain the reason.

Ans :

(i) Acid rain reacts with marble (calcium

differences.

Ans :

(i) Ozone absorbs UV radiation, whereas greenhouse gases trap heat.
(ii) Ozone protects life from UV rays, whereas greenhouse gases cause warming.
(iii) Ozone is mainly in the stratosphere, whereas greenhouse gases are present throughout the atmosphere.

171. A factory switches from coal to cleaner fuel. Explain how this helps reduce air pollution.

Ans :

(i) Cleaner fuels release fewer pollutants.
(ii) Emission of sulphur dioxide decreases.
(iii) The chances of acid rain formation reduce.

172. An increase in nitrogen dioxide concentration is reported in a city. Explain its effects on humans and plants.

Ans :

(i) It causes irritation of the respiratory tract.
(ii) It can lead to lung congestion.
(iii) It damages plant leaves.

173. Scientists predict that continued global warming will increase the frequency of floods in coastal regions. Explain.

Ans :

(i) Global warming melts glaciers and ice caps.
(ii) Sea levels rise gradually.
(iii) Coastal flooding becomes more common.

174. Why is the depletion of the ozone layer considered a global environmental concern?

Ans :

(i) More UV rays reach the Earth's surface.
(ii) Skin diseases and health problems increase.
(iii) Plants and animals are also adversely affected.

175. A city launches a campaign encouraging people to use bicycles instead of cars. Explain how this can benefit the environment.

Ans :

(i) Less fossil fuel is burned.
(ii) Carbon dioxide emissions decrease.
(iii) Air pollution and global warming are reduced.

176. A scientist finds that an area with high industrial activity receives more acidic rainfall than neighbouring regions. Explain.

Ans :

(i) Industries release sulphur dioxide and nitrogen oxides.
(ii) These gases react with water vapour to form acids.
(iii) The acids fall as acid rain.

177. An environmental report states that reducing fossil fuel consumption is essential for the future. Give three reasons.

Ans :

(i) It reduces greenhouse gas emissions.
(ii) It lowers air pollution.
(iii) It helps control global warming and acid rain.

178. What is global warming? What is its cause? Also, write the effect of global warming.

Ans :

The rise in temperature of the earth's surface is called global warming. It is caused due to the trapping of sun's radiation by carbon dioxide in the atmosphere. This process is called greenhouse effect. The various effects of global warming are:

(i) It will lead to the melting of the glaciers and the polar ice caps which would lead to submerging of low lying coastal areas.
(ii) Global warming increases the water vapour in the atmosphere which will contribute further in increasing the temperature of the earth.

179. What are greenhouse gases? Write the ways of reducing the greenhouse gases in the atmosphere.

Ans :

The gases which causes the greenhouse effect are called greenhouse gases, which includes carbon dioxide, methane, water vapour, ozone, chlorofluorocarbons, nitrous oxide, etc.

Ways of reducing the greenhouse gases in the atmosphere:

(i) Afforestation: Plant more trees, save forests, increase green cover.
(ii) Minimum use of automobiles: Use more of public transport, car pools, ride bicycles for shorter distances etc.
(iii) Burning of fossil fuels should be minimized.

180. Acid rain has a very adverse effect on the soil chemistry, the water bodies, buildings and vegetation. Justify?

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Ans :

Acid rain has a very adverse affect on the soil chemistry, the water bodies, buildings and the vegetation:

(i) Acid rain removes the basic essential nutrients from the soil.
(ii) Acid rain increases the acidic character of the water bodies and thus the water becomes unfit for the survival of the aquatic animals like fishes.
(iii) Acid rain basically damages the leaves of the plants.
(iv) It has harmful effect on the sculptures monument and buildings made of limestone, marbles and metals.

181. What are the adverse effect of nitrogen dioxide?

Ans :

Nitrogen dioxide is a major atmospheric pollutant and adversely effects the human beings, plants and animals. The adverse effects of NO_2 are as follows:
(i) It causes irritation in mucous membrane.
(ii) Large quantities of NO_2 can lead to serious lung congestion and in same cases, can prove fatal.
(iii) The presence of nitrogen dioxide severely damages the leaves of the plants.
(iv) Nitrogen dioxide in the presence of light oxidizes hydrocarbon leading to the formation of photochemical smog which cause irritation in eyes, asthma attack and other respiratory tract infections.

182. Define 'Depletion of ozone layer'. Write two main causes of the depletion of ozone layer.

Ans :

Decrease of the ozone in the stratosphere is called the depletion of the ozone layer or the destruction of the ozone layer.
The main causes of the depletion of ozone layer are:
(i) Excessive use of chlorofluorocarbons.
(ii) Flying of supersonic planes.

FOUR MARKS QUESTIONS

183. A factory situated near a city continuously releases sulphur dioxide and nitrogen oxides into the atmosphere. After a few years, the nearby lake, vegetation and buildings show visible damage. Explain how these pollutants lead to such effects.

Ans :

(i) Sulphur dioxide and nitrogen oxides react with oxygen and water vapour.
(ii) They form sulphuric acid and nitric acid.
(iii) These acids fall as acid rain.
(iv) Acid rain damages vegetation, aquatic life and buildings.

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184. A scientist predicts that the average temperature of the Earth will continue to rise in the coming decades. Explain how greenhouse gases contribute to this phenomenon and mention one possible consequence.

Ans :

(i) Greenhouse gases absorb outgoing infrared radiation.
(ii) The heat gets trapped in the atmosphere.
(iii) This increases the Earth's temperature.
(iv) One consequence is the melting of glaciers and polar ice caps.

185. A city experiences frequent photochemical smog during summer afternoons. Explain the formation of photochemical smog and its effects on human health.

Ans :

(i) Nitrogen dioxide reacts in the presence of sunlight.
(ii) Photochemical smog is formed.
(iii) It causes eye irritation and breathing difficulties.
(iv) It may trigger asthma attacks and respiratory infections.

186. A student compares the role of the ozone layer and greenhouse gases in the atmosphere. Differentiate between them.

Ans :

(i) Ozone absorbs harmful UV rays.
(ii) Greenhouse gases trap infrared radiation.
(iii) Ozone protects life from UV damage.
(iv) Greenhouse gases contribute to global warming.

187. The Taj Mahal is gradually losing its shine due to environmental pollution. Explain the role of acid rain in this process.

Ans :

(i) Industries release SO_2 and NO_2 into the atmosphere.
(ii) These gases form acids in rainwater.
(iii) Acid rain reacts with marble (calcium carbonate).
(iv) The marble surface gets corroded and loses its shine.

188. A country plans to reduce the use of fossil fuels. Explain how this measure can help in controlling both air pollution and global warming.

Ans :

(i) Less fossil fuel burning reduces harmful pollutants.
(ii) Emission of sulphur dioxide and nitrogen oxides decreases.
(iii) Carbon dioxide emissions also decrease.
(iv) This helps reduce air pollution and global warming.

189. An environmental report suggests afforestation as an effective method to combat climate change. Explain.

Ans :

(i) Trees absorb carbon dioxide during photosynthesis.
(ii) Carbon dioxide is a greenhouse gas.
(iii) Reduction in carbon dioxide decreases heat trapping.
(iv) This helps control global warming.

190. A lake ecosystem is severely affected after years of acid rain. Explain the changes that may occur in the lake and surrounding environment.

Ans :

(i) Water becomes more acidic.
(ii) Fish and aquatic organisms may die.
(iii) Soil nutrients are removed.
(iv) Plant growth around the lake is affected.

191. Explain how excessive use of chlorofluorocarbons (CFCs) can affect life on Earth.

Ans :

(i) CFCs destroy ozone molecules.
(ii) Ozone layer becomes thinner.
(iii) More UV rays reach the Earth.
(iv) Skin diseases and ecological damage increase.

192. A teacher says that the troposphere is the most important atmospheric layer for life. Justify the statement.

Ans :

(i) It contains most of the atmospheric gases.
(ii) It contains nearly all water vapour.
(iii) Clouds and rainfall occur in this layer.
(iv) Most living organisms depend on it directly.

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193. A city introduces electric buses to replace diesel buses. Explain how this step benefits the environment.

Ans :

(i) Air pollutant emissions decrease.
(ii) Carbon dioxide emissions are reduced.
(iii) Air quality improves.
(iv) Global warming can be controlled to some extent.

194. An industrial area records higher levels of respiratory diseases than a rural area. Explain the possible reasons.

Ans :

(i) Industries release harmful gases.
(ii) Sulphur dioxide and nitrogen dioxide pollute the air.
(iii) These gases irritate the respiratory system.
(iv) Health problems become more common.

195. Explain the formation of acid rain due to sulphur dioxide.

Ans :

(i) Sulphur dioxide is released into the atmosphere.
(ii) It combines with oxygen to form sulphur trioxide.
(iii) Sulphur trioxide reacts with water.
(iv) Sulphuric acid is formed, causing acid rain.

196. Explain the formation of acid rain due to nitrogen oxides.

Ans :

(i) Nitrogen and oxygen combine at high temperatures in engines.
(ii) Nitric oxide is formed.
(iii) It gets converted into nitrogen dioxide.
(iv) Nitrogen dioxide forms nitric acid, leading to acid rain.

197. A student notices that coastal areas are more vulnerable to global warming than inland regions. Explain.

Ans :

(i) Global warming melts glaciers and ice caps.
(ii) Sea levels rise gradually.
(iii) Coastal areas may get submerged.
(iv) Flooding becomes more frequent.

(d) Increased exposure to harmful UV-B radiation reaching the earth's surface due to the depletion of the ozone layer is most strongly linked to causing skin cancer in humans.

218. Kavita is reading a botanical journal about the severe damage caused to vegetation in highly industrialised zones. The journal includes a case study of a region where a dark, thick, soot-laden fog often blankets the city. This atmospheric condition is described as a mixture of oxides of nitrogen and sulphur, along with partially-oxidised hydrocarbons. Kavita notes that the leaves of many local plants exhibit strange injuries and that agricultural productivity in the area has drastically decreased. She decides to compile a report on how specific gaseous pollutants affect both plant health and human visibility.

(a) Name the specific pollutant described as a dark, thick, dust and soot-laden fog.

(b) State the specific name of the leaf injury caused to plants by sulphur dioxide.

(c) Name the trace gas formed when oxides of nitrogen react with hydrocarbons in the atmosphere.

(d) Name the pollutant gas that significantly reduces crop growth and simultaneously causes irritation to human eyes.

Ans :

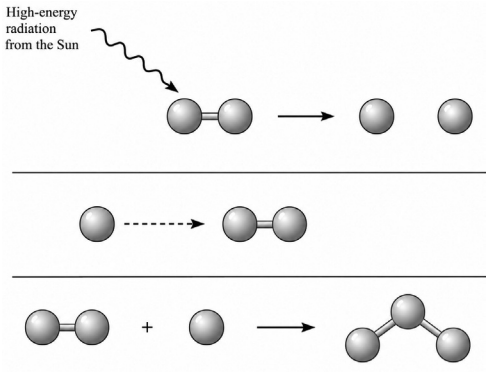
(a) The specific pollutant described as a dark, thick, dust and soot-laden fog is called smog, produced by industries and automobiles combining partially-oxidised hydrocarbons and various gaseous oxides.

(b) Sulphur dioxide gas possesses a very damaging effect on local vegetation, as it directly causes severe and noticeable leaf injuries to plants which are scientifically called necrotic blotching.

(c) The trace gas formed when atmospheric oxides of nitrogen react with airborne hydrocarbons under specific environmental conditions, ultimately causing photochemical smog, is known as ozone.

(d) Hydrogen sulphide gas is a harmful air pollutant that significantly reduces general crop growth in agricultural fields and simultaneously causes severe acute irritation to human eyes.

219. Rohan is studying the chemical reactions that take place in the region of the atmosphere located between 10 to 40 kilometres above the earth's surface. He examines a scientific chart illustrating how high-energy solar radiation interacts with diatomic molecules. The chart demonstrates a continuous cycle of generation and destruction that maintains a dynamic equilibrium. Rohan uses this visual information to understand how a pale-blue gas is naturally produced.



(a) Name the specific layer of the atmosphere where this interaction occurs and state the percentage of the earth's protective pale-blue gas situated there.

(b) Name the specific process shown in the diagram where solar radiation splits the diatomic molecule.

(c) Write the two balanced chemical equations with state symbols that represent the sequential chemical reactions described in the image.

Ans :

(a) This natural interaction occurs in the stratosphere, a region located between 10 to 40 kilometres above the earth's surface, which contains nearly 90% of the earth's protective ozone gas.

(b) The specific natural process shown in the diagram, where high-energy solar ultraviolet radiations split atmospheric oxygen molecules into individual oxygen atoms, is scientifically called photolysis.

(c) 1. High energy ultra-violet radiations break down diatomic oxygen molecules into oxygen atoms. The balanced chemical equation is:

$$O_2(g) + UVO \rightarrow (g) + O(g).$$

2. The isolated oxygen atom then successfully combines with another intact oxygen molecule to form ozone. The balanced chemical equation is:

$$O_2(g) + O(g) \rightarrow O_3(g).$$

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(c) Absorbs harmful UV rays.
(d) Excessive use of CFCs.

207. The government launches a campaign encouraging citizens to use bicycles, public transport and electric vehicles.
(a) Which environmental issue is the campaign targeting?
(b) Name one greenhouse gas whose emission will decrease.
(c) State one advantage of using public transport.
(d) State one environmental benefit of electric vehicles.

Ans :
(a) Global warming.
(b) Carbon dioxide.
(c) Less fuel consumption.
(d) Reduced air pollution.

208. Study the following information:
- Factory A uses coal as fuel.
- Factory B uses solar energy.

(a) Which factory is likely to contribute more to air pollution?
(b) Name one pollutant released.
(c) State one effect of this pollutant on human health.
(d) Suggest one way to reduce such pollution.

Ans :
(a) Factory A.
(b) Sulphur dioxide.
(c) Respiratory irritation.
(d) Use cleaner fuels.

209. An environmental report states that fish populations in a freshwater lake have decreased drastically.
(a) Which type of pollution may be responsible?
(b) How does this affect the lake water?
(c) Why do fishes fail to survive?
(d) Name the atmospheric phenomenon linked to this problem.

Ans :
(a) Acidification of water.
(b) Water becomes acidic.
(c) Acidic conditions are unsuitable for aquatic life.
(d) Acid rain.

210. A pilot is flying at an altitude of 25 km above sea level.
(a) In which atmospheric layer is the aircraft flying?
(b) Which important protective layer is present there?
(c) What is its function?
(d) What would happen if this layer becomes thinner?

Ans :
(a) Stratosphere.
(b) Ozone layer.
(c) Absorbs UV rays.
(d) More UV rays would reach Earth.

211. A city records the following changes over 20 years:
- Increase in average temperature
- Rise in sea level
- More heat waves

(a) Which environmental issue is indicated?
(b) Name two greenhouse gases responsible.
(c) State one cause of the increase in these gases.
(d) Mention one long-term consequence.

Ans :
(a) Global warming.
(b) Carbon dioxide and methane.
(c) Burning of fossil fuels.
(d) Submergence of coastal areas.

212. An environmental club conducts a survey and finds that areas with dense vegetation have cleaner air than urban centres.
(a) Why do trees help improve air quality?
(b) Which greenhouse gas is absorbed by plants?
(c) What process enables plants to absorb this gas?
(d) Name this environmental strategy.

Ans :
(a) Trees absorb pollutants and carbon dioxide.
(b) Carbon dioxide.
(c) Photosynthesis.
(d) Afforestation.

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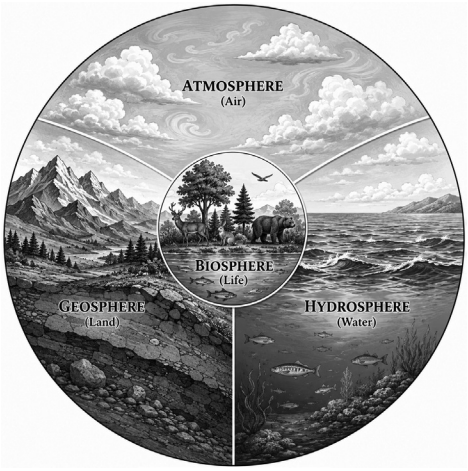
CASE BASED QUEATIONS

213. Rahul visits an industrial area during a heavy thunderstorm accompanied by intense lightning. He collects a sample of the falling rainwater

222. Priya is reading the first chapter of her environmental chemistry textbook to understand the fundamental components of her surroundings. She examines a pie-chart style illustration that divides the earth into distinct physical and biological regions. The text explains that human survival depends on the continuous interaction between a gaseous cover, a liquid component covering 75% of the surface, and a solid component. Priya creates a summary of these major components for her upcoming exam.



(a) Identify the three physical components of the environment shown in the diagram and state what the solid component consists of.

(b) Name the central overlapping region shown in the diagram where living organisms interact, and identify the noble gas present as a minor component in the gaseous cover.

Ans :

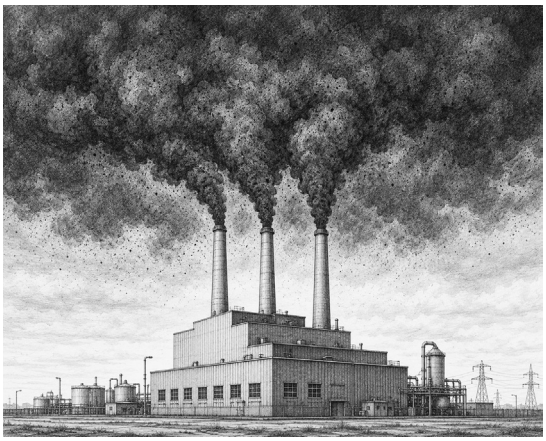
(a) 1. The three primary physical components of the earth's environment illustrated in the overlapping diagram are the atmosphere, the hydrosphere, and the solid lithosphere.

2. The lithosphere is the solid component of the earth's natural environment, and it entirely consists of physical formations like towering mountains, natural rocks, and surface soil.

(b) 1. The central overlapping region shown in the diagram, with which all living organisms such as plants and animals constantly interact, is known as the biosphere.

2. According to the environmental composition, the specific noble gas that is present merely as a minor component within the earth's gaseous atmospheric cover is argon.

223. Tarun is analysing an environmental report regarding the degradation of air quality in a developing industrial town. The report includes a schematic illustration of a large manufacturing facility actively releasing waste products into the surrounding air. Tarun notes that these emissions consist of both gaseous and suspended solid pollutants that are highly detrimental to human respiration. He researches industrial methods to control this specific type of pollution before it leaves the exhaust pipes.



(a) Define the term air pollution as given in the text.

(b) Name the specific particulate pollutant mentioned in the text that consists of solids suspended in smoke, dust, and vapour.

(c) State how small suspended particles in smoke gradually affect the human respiratory system.

(d) Identify two specific devices mentioned in the text that should be employed in such industries to control air pollution.

Ans :

(a) Air pollution fundamentally means the degradation of the quality of air due to the concentration of harmful contaminants that negatively affects human, plant, and animal lives.

(b) The specific particulate pollutant mentioned in the text that consists of harmful solids suspended in smoke, atmospheric dust, and chemical vapour is Suspended Particulate Matter (SPM).

(c) When extremely small suspended solid particles from industrial smoke get lodged inside the human lungs, they gradually damage the functioning of lungs and cause lung cancer.

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(a) 1. The toxic, odourless gas mentioned in the scenario is carbon monoxide (CO), which is produced from the incomplete burning of petrol and diesel in motor vehicles.
2. Carbon monoxide is extremely hazardous because it actively prevents haemoglobin from carrying vital oxygen to different parts of the human body, causing severe respiratory difficulties.

(b) 1. The heavy metal pollutant released into the air through the exhaust of motor vehicles that use specific fuel additives like tetraethyl lead is simply known as lead.
2. Lead enters the air and impairs the body's metabolic activities; it severely damages the nervous and digestive systems of humans and can ultimately cause deadly cancer.

216. Sameer conducts an environmental science project on the impact of industrial emissions on nearby aquatic ecosystems. He observes that a large thermal power plant is burning fossil fuels and releasing large quantities of a suffocating gas formed by the combustion of coal. He takes water samples from a nearby lake and finds that the water has a pH of 3.8, which is highly dangerous for aquatic plants and animals. His research indicates that the gaseous emissions dissolve in water to form a strong mineral acid. Sameer documents how this acidic water washes soil nutrients and severely impacts marine animals living in the lake.

(a) Write the two balanced chemical equations with state symbols showing the conversion of sulphur dioxide into sulphuric acid in the atmosphere.

(b) State the specific pH threshold below which most aquatic animals cannot live, and describe the effect of this acid rain on the soil biology.

Ans :

(a) 1. Sulphur dioxide reacts with oxygen to form sulphur trioxide. The balanced chemical equation for this atmospheric oxidation process is: $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$.
2. Sulphur trioxide then dissolves in atmospheric water vapour to form strong sulphuric acid. The balanced chemical equation for this dissolution is:

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

(b) 1. Most marine animals cannot survive when the pH of aquatic waterways drops below 4, and some specific species of fish will die when the pH is less than 5.5.

2. Acid rain severely washes away essential nutrients and minerals from the soil, heavily damaging soil biology and killing microbes that are unable to tolerate changes to low pH.

217. Vikram is studying stratospheric chemistry and learns about a highly stable class of chemicals used historically in air-conditioning systems. He reads that these non-toxic and non-inflammable compounds do not dissolve in rain and are carried by winds into the upper atmosphere. Once there, they are exposed to powerful solar radiations which break them apart to release highly reactive free radicals. Vikram discovers that a single such free radical can destroy millions of molecules of a pale-blue gas situated 10 to 40 kilometres above the earth. He notes these reactions to understand the chemical mechanism behind the thinning of this protective layer.

(a) Name the specific class of Ozone Depleting Substances (ODS) described in the scenario.

(b) Write the balanced chemical equation with state symbols showing the breakdown of CF_2Cl_2 by powerful solar radiation.

(c) Write the balanced chemical equation with state symbols showing how the released free radical reacts with ozone.

(d) Name the specific disease in humans that is most commonly linked to increased exposure to UV-B radiation due to this depletion.

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Ans :

(a) The specific class of highly stable Ozone Depleting Substances (ODS) used as refrigerants and cleaning agents described in the scenario is chlorofluorocarbons, also called CFCs or freons.

(b) In the upper stratosphere, powerful ultraviolet radiation breaks down these freons to release free radicals. The balanced chemical equation for this process is:

$$CF_2Cl_2(g) \rightarrow Cl(g) + CF_2Cl(g).$$

(c) The highly reactive chlorine free radical destroys the stratospheric ozone molecules, forming chlorine monoxide. The balanced chemical equation is:

$$Cl(g) + O_3(g) \rightarrow ClO(g) + O_2(g).$$

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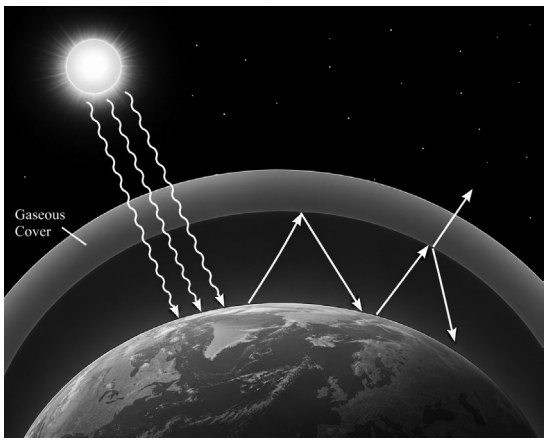
220. Meera is preparing a presentation on the environmental impact of deforestation and excessive burning of fossil fuels. She includes an illustration in her slides that demonstrates how certain atmospheric gases act like a soft blanket around the planet. She explains how this phenomenon prevents too much solar radiation from escaping back into space.



(a) Name the environmental phenomenon depicted in the diagram and identify two chemical species responsible for it.

(b) State the term used for the natural phenomenon that would occur if there were absolutely none of these gases in the atmosphere, as happened in the distant past.

(c) Describe two harmful effects of this phenomenon on global rain patterns and on low-lying coastal areas in countries like India.

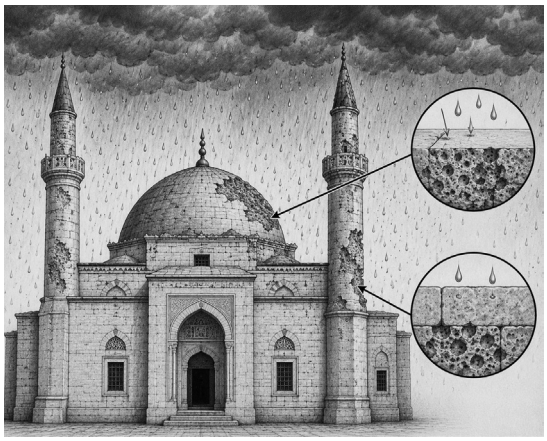
Ans :

(a) The environmental phenomenon clearly depicted in the diagram is the greenhouse effect, and two important chemical species responsible for this are carbon dioxide and methane.

(b) If there were no greenhouse gases present in the atmosphere to trap heat, too much solar radiation would escape, and the earth would become a big snowball.

(c) 1. Global warming can significantly lead to drastic changes in worldwide rain patterns, which will negatively affect trees in forests and thus heavily disrupt regional agricultural productivity.
2. The melting of glaciers and polar ice caps will cause sea levels to rise, which will in turn flood several low-lying coastal areas in countries like India.

221. Arun visits an ancient monument made entirely of white marble that has stood for centuries. He notices extensive structural damage and surface discoloration on the exterior walls, which his guidebook attributes to atmospheric contaminants dissolving in precipitation. The guidebook features a structural illustration demonstrating how historical buildings undergo chemical deterioration. Arun learns that certain gaseous emissions drastically alter the composition of rainfall, leading to severe architectural degradation.



(a) Name two specific mineral acids formed in the atmosphere that cause the type of structural damage shown in the diagram.

(b) State the specific term used to describe this acidic precipitation and explain how its impact can be reduced by using alternative transport technologies.

Ans :

(a) 1. One specific mineral acid formed by the dissolution of atmospheric gaseous pollutants in falling rainwater that causes severe damage to building materials is strong nitric acid.
2. Another powerful mineral acid formed when oxides of sulphur dissolve in atmospheric moisture, heavily weakening marble and limestone structures due to its dissolving action, is sulphuric acid.

(b) 1. This highly corrosive precipitation that damages marble buildings, historical statues, and metallic structures due to a dissolved mixture of mineral acids is specifically called acid rain.
2. The impact of this acidic precipitation can be greatly reduced if transport vehicles are fitted with catalytic converters to successfully reduce the emission of harmful nitric oxide.

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198. Explain why reducing automobile use can help protect the atmosphere.

Ans :

(i) Less fuel is burned.
(ii) Carbon dioxide emissions decrease.
(iii) Nitrogen oxide emissions decrease.
(iv) Air pollution and global warming are reduced.

199. A scientist states that ozone is continuously formed and destroyed in the atmosphere. Explain how ozone is formed.

Ans :

(i) UV rays act on oxygen molecules.
(ii) Oxygen molecules split into oxygen atoms.
(iii) Oxygen atoms combine with oxygen molecules.
(iv) Ozone is formed.

200. Why is the depletion of the ozone layer considered a serious environmental problem?

Ans :

(i) Harmful UV rays reach the Earth.
(ii) Risk of skin diseases increases.
(iii) Plants and animals are affected.
(iv) Ecological balance is disturbed.

201. An environmental survey reveals a steady increase in greenhouse gases over the last decade. Explain the likely environmental consequences.

Ans :

(i) More heat is trapped in the atmosphere.
(ii) Earth's temperature increases.
(iii) Glaciers and polar ice caps melt.
(iv) Sea levels rise.

202. A student is asked to suggest four measures to reduce atmospheric pollution. State them.

Ans :

(i) Afforestation.
(ii) Reduced use of automobiles.
(iii) Use of public transport.
(iv) Minimise burning of fossil fuels.

203. A newspaper reports that a hill town has witnessed frequent landslides, melting glaciers and irregular rainfall over the last decade.
(a) Name the environmental phenomenon responsible for these changes.
(b) What is the main greenhouse gas responsible for this phenomenon?
(c) Explain how this gas increases the Earth's temperature.
(d) Suggest one measure that can help reduce this problem.

Ans :

(a) Global warming.
(b) Carbon dioxide.
(c) It traps infrared radiations in the atmosphere.
(d) Afforestation/reduced use of fossil fuels.

204. A scientist collected rainwater samples from two cities. The pH of City A was found to be much lower than that of City B.
(a) Which type of rain is likely to occur in City A?
(b) Name two gases responsible for this condition.
(c) How are these gases introduced into the atmosphere?
(d) State one harmful effect on buildings.

Ans :

(a) Acid rain.
(b) Sulphur dioxide and nitrogen dioxide.
(c) By industries and burning of fossil fuels.
(d) Corrosion of buildings and monuments.

205. A marble statue near an oil refinery has developed rough patches and lost its shine.
(a) Which environmental problem is responsible?
(b) Name the acid mainly responsible for the damage.
(c) How is this acid formed in the atmosphere?
(d) Name one famous Indian monument affected by the same problem.

Ans :

(a) Acid rain.
(b) Sulphuric acid.
(c) $SO_2 \rightarrow SO_3 \rightarrow H_2SO_4$.
(d) Taj Mahal.

206. A student observes that the number of skin-related diseases has increased in a region over the past few years.
(a) Which atmospheric layer may have been affected?
(b) Name the gas present in this layer.
(c) What is the function of this gas?
(d) Name one major cause of its depletion.

Ans :

(a) Stratosphere.
(b) Ozone.

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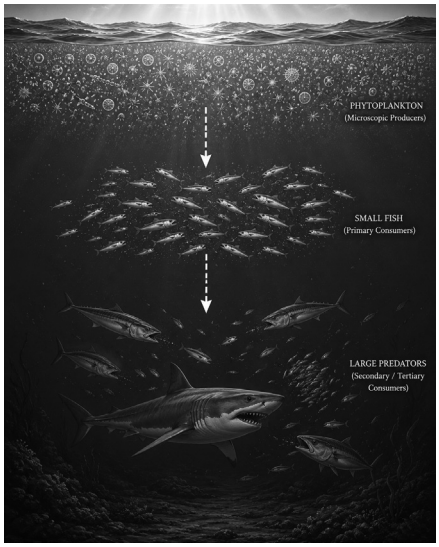
(d) To effectively control industrial air pollution and minimise toxic atmospheric emissions, factories should employ specific mechanical devices such as air filters and electrostatic smoke precipitators.

224. Ananya is reviewing a marine biology article that discusses the cascading effects of atmospheric changes on ocean life. The article features a marine food web illustration demonstrating how microscopic surface-dwelling organisms form the basis of the entire aquatic ecosystem. She learns that increased exposure to a specific type of high-energy radiation threatens the survival of these foundational organisms. Ananya notes that if these microscopic organisms perish, all higher animals in the food chain will eventually die out.



(a) Name the most basic microscopic organisms found over the surface of seas that are threatened by increased radiation.

(b) State the specific type of radiation, including its wave length range, that is effective in causing this damage to marine life.

(c) Name the specific agricultural crop mentioned in the text whose growth is adversely affected because the cyanobacteria on its roots are sensitive to this radiation.

(d) State the effect of this radiation on the chlorophyll content of plants and its subsequent result.

Ans :

(a) The most basic microscopic organisms found floating in and over the surface of seas, which are severely threatened by environmental ozone depletion, are called phytoplankton.

(b) The specific harmful radiation that damages marine life is Solar Ultraviolet-B (UV-B) radiation, which operates within an effective wave length range of 280 to 315 nm.

(c) The economically important agricultural crop whose growth is adversely affected because the vital nitrogen-retaining cyanobacteria residing on its roots are sensitive to UV radiation is rice.

(d) Increased exposure to powerful UV radiation significantly reduces the essential chlorophyll content of the plants, and this resultant loss thereby heavily affects the overall quality of vegetables.

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in a clean glass beaker to test it in his school laboratory. Upon testing with a universal indicator, he discovers that the pH of the water sample is approximately 3.5. His chemistry teacher explains that the high temperatures from lightning cause atmospheric gases to combine. She notes that this process ultimately forms strong mineral acids which dissolve in the rainwater, making it significantly more acidic than normal precipitation.

(a) Write the balanced chemical equation with state symbols for the reaction of nitrogen and oxygen at high temperatures.

(b) State the chemical formula of the weak acid formed in normal rainwater that gives it a pH of 5.6.

(c) Write the two balanced chemical equations with state symbols showing how nitrogen dioxide interacts with rain to form nitric acid.

Ans :

(a) The balanced chemical equation for the reaction of nitrogen and oxygen at high temperatures is: $N_2(g) + O_2(g) \rightarrow 2NO(g)$.

(b) The chemical formula of the weak acid formed in normal rainwater, giving it a pH of approximately 5.6, is carbonic acid, written as H_2CO_3.

(c) 1. Nitric oxide gas gets oxidised by the oxygen present in the atmosphere to successfully form nitrogen dioxide gas. The balanced equation is: $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

2. Nitrogen dioxide strongly interacts with falling rain or snow on its way down to the earth, forming liquid nitric acid. The balanced equation is:

$$4NO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 4HNO_3(aq).$$

214. Neha attends a seminar on climate change where the speaker discusses how human activities have altered the atmospheric composition. She learns that the excessive burning of fossil fuels and the use of hot water in homes contribute massively to the emission of carbon dioxide. The speaker emphasizes that if these emissions continue unchecked, the earth could become less habitable with more violent and unpredictable weather. Neha is surprised to learn that simple lifestyle changes, such as turning off electronic devices, can save thousands of pounds of this gas. Inspired by the seminar, she decides to implement energy-saving practices at her home to help restrain this environmental issue. She also plans to educate her neighbours about the benefits of using alternative energy.

(a) Define the term greenhouse effect as given in the chapter.

(b) State the main source of water vapour as a greenhouse gas in the atmosphere.

(c) Describe two specific ways mentioned in the text by which individuals can reduce carbon emissions and restrain global warming in their daily lives.

Ans :

(a) The greenhouse effect is the heating of the planet and its surroundings brought on by solar energy that is absorbed by carbon dioxide and water vapour in the atmosphere.

(b) The main source of water vapour acting as a greenhouse gas in the atmosphere is the continuous burning of hydrocarbons, which produces carbon dioxide and water vapour.

(c) 1. Individuals can greatly restrain global warming by using less hot water, as heating cold water requires lots of energy, saving 500 pounds of carbon every year.

2. People can simply turn off their electronic devices like televisions, music systems, and laptops if they are not using them, saving thousands of pounds of carbon dioxide.

215. Anjali was reading an article about urban health hazards in a densely populated city with heavy automobile traffic. She noticed that many people living near the main highways were suffering from severe respiratory and metabolic issues. The article mentioned that older vehicles running on specific types of fuel release a highly toxic, odourless gas that interferes with blood oxygen transport. It also highlighted that certain fuel additives used in the past released heavy metal particulates into the air. Anjali decided to research how these specific vehicular emissions directly impact human physiological functions.

(a) Name the toxic, odourless gas mentioned in the scenario and explain its exact harmful effect on the human bloodstream.

(b) Identify the heavy metal pollutant released from motor vehicles using tetraethyl lead, and state its impact on the human body.

Ans :

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